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Murayama

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(54) **IMAGE FORMING APPARATUS HAVING BEARING BODY AND CLEANING UNIT**

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G03G 15/00 (2006.01)
G03G 15/16 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/5054*** (2013.01); ***G03G 15/161*** (2013.01); *G03G 15/2003* (2013.01); *G03G 15/2064* (2013.01); *G03G 15/2078* (2013.01); *G03G 15/5004* (2013.01); *G03G 2215/1661* (2013.01); *G03G 2215/2016* (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/20
USPC 399/71
See application file for complete search history.

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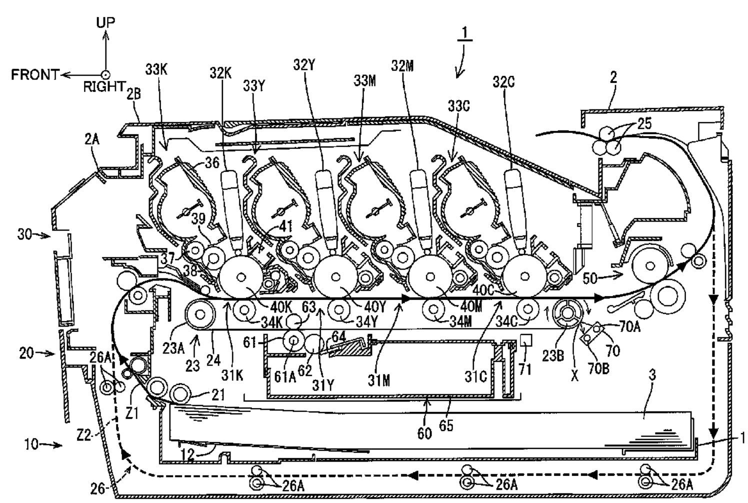
(57) **ABSTRACT**

In an image forming apparatus, when it is determined that a pre-execution condition is satisfied, a cleaning unit is brought from a first state into a second state and is controlled to clean the bearing body. When it is determined that an execution condition is satisfied, a pattern acquisition is executed to form a pattern image on the bearing body by using an image forming section and to acquire characteristics of the pattern image based on detection results. The pre-execution condition includes a condition that a correlation value satisfies a first condition. The correlation value is correlated with an amount of deviation in characteristics of images formed by the image forming section. The execution condition includes a condition that the correlation value satisfies a second condition. The correlation value satisfies the first condition before satisfying the second condition.

14 Claims, 7 Drawing Sheets



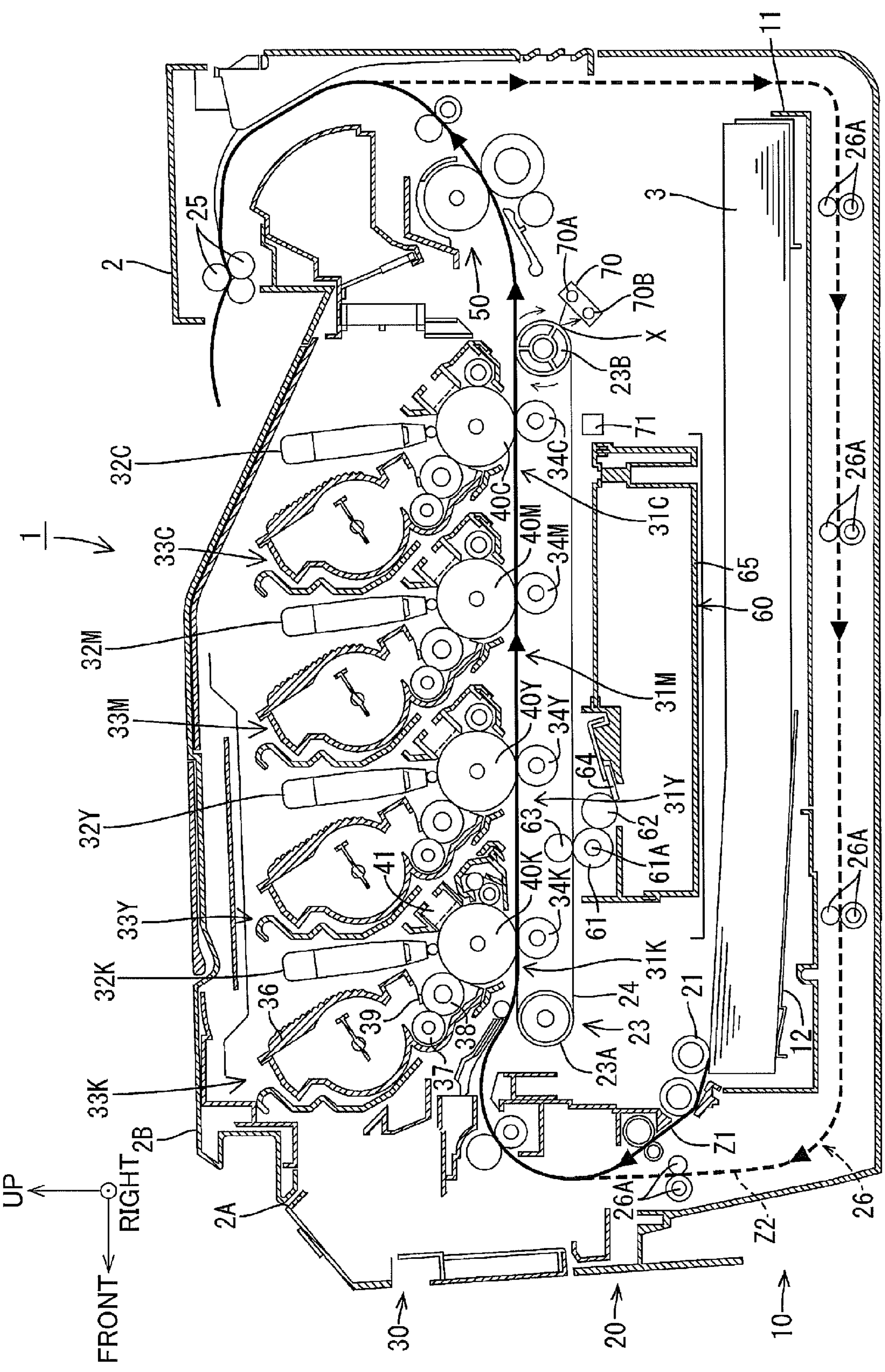

UP
FRONT
RIGHT
1
2
2A
2B
3
10
11
12
20
21
23
23A
23B
24
25
26
26A
30
31C
31K
31M
31Y
32C
32K
32M
32Y
33C
33K
33M
33Y
34C
34K
34M
34Y
36
37
38
39
40C
40K
40M
40Y
41
50
60
61
61A
62
63
64
65
70
70A
70B
71
X
Z1
Z2

FIG. 1

FIG. 2

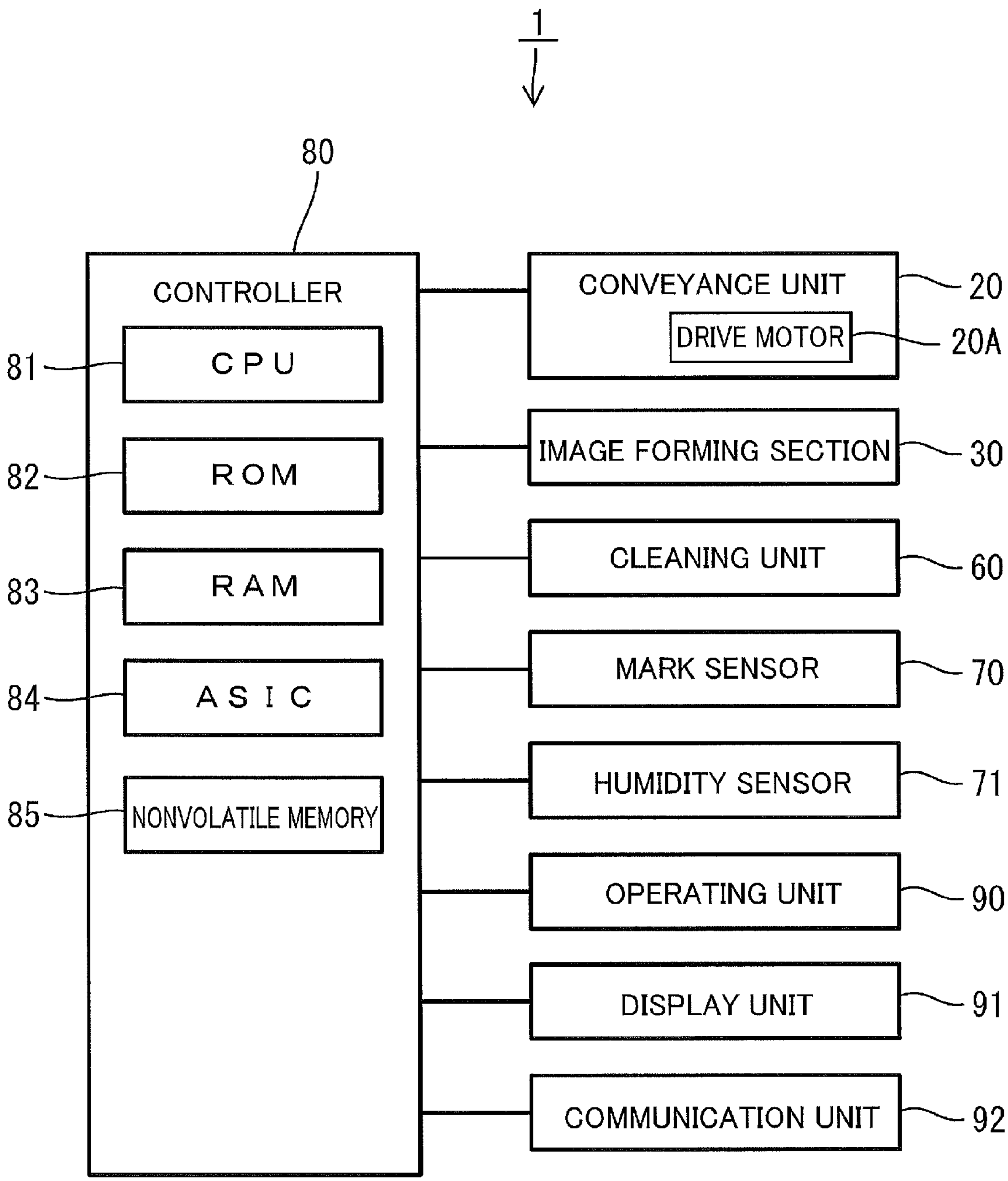

1
80
CONTROLLER
81
CPU
82
ROM
83
RAM
84
ASIC
85
NONVOLATILE MEMORY
CONVEYANCE UNIT
20
DRIVE MOTOR
20A
IMAGE FORMING SECTION
30
CLEANING UNIT
60
MARK SENSOR
70
HUMIDITY SENSOR
71
OPERATING UNIT
90
DISPLAY UNIT
91
COMMUNICATION UNIT
92

FIG. 3

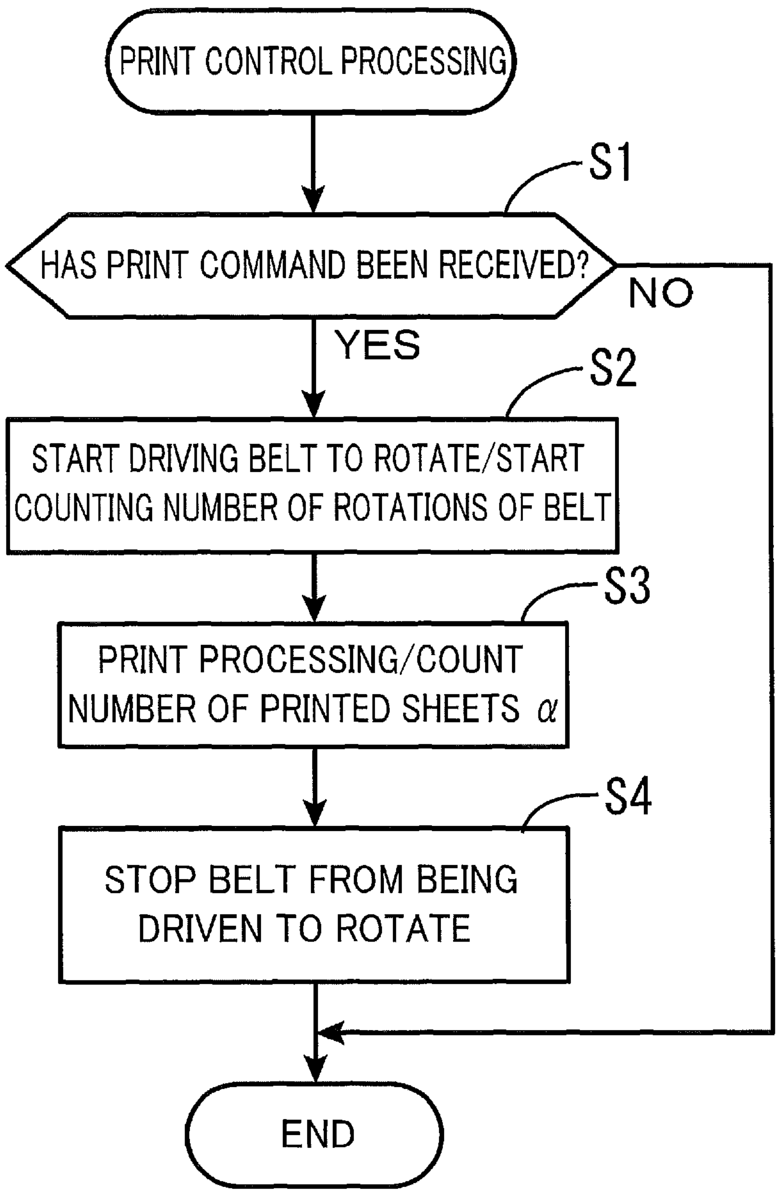

PRINT CONTROL PROCESSING
S1
HAS PRINT COMMAND BEEN RECEIVED?
NO
YES
S2
START DRIVING BELT TO ROTATE/START COUNTING NUMBER OF ROTATIONS OF BELT
S3
PRINT PROCESSING/COUNT NUMBER OF PRINTED SHEETS α
S4
STOP BELT FROM BEING DRIVEN TO ROTATE
END

FIG. 4

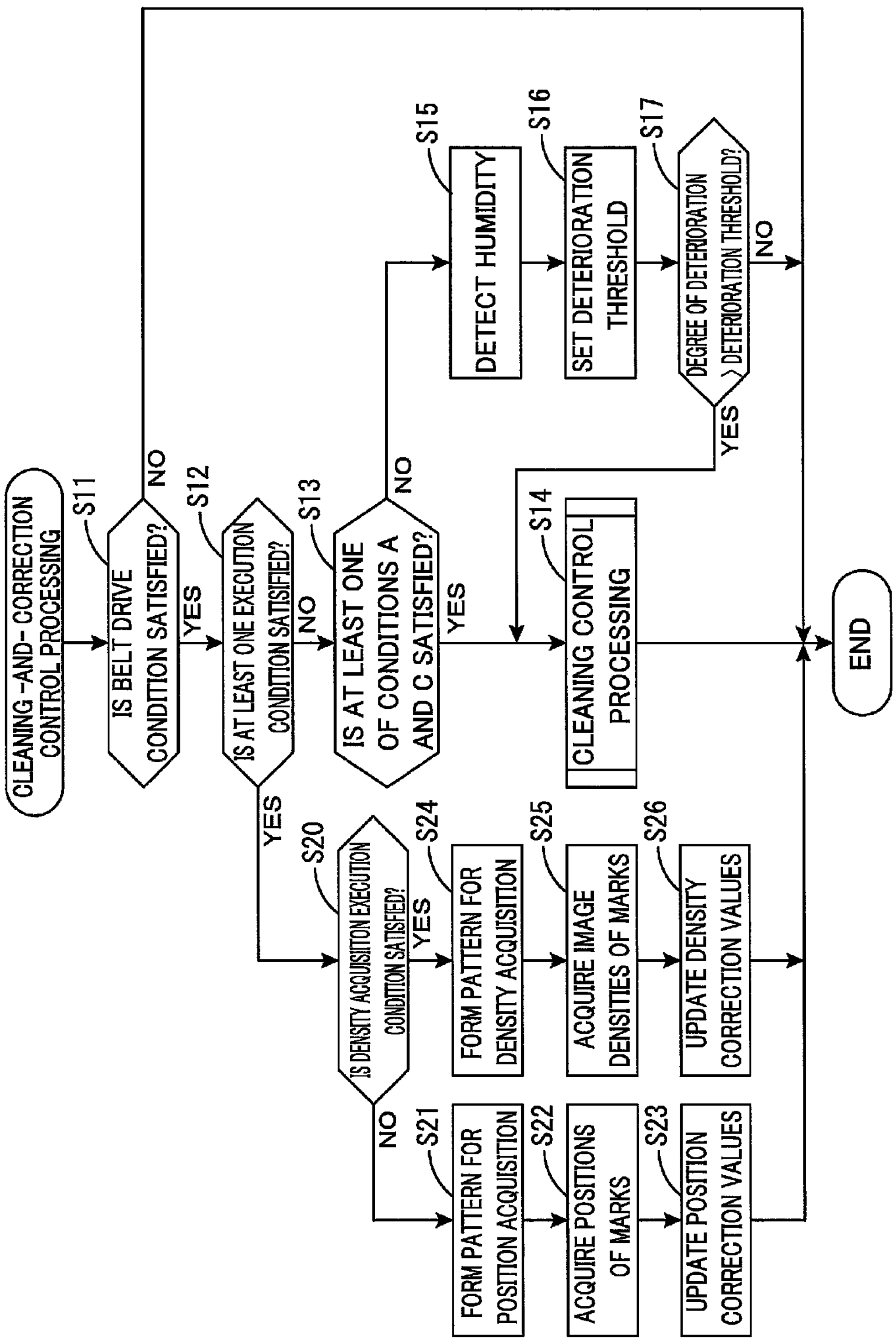

CLEANING-AND-CORRECTION CONTROL PROCESSING
S11
IS BELT DRIVE CONDITION SATISFIED?
YES
NO
S12
IS AT LEAST ONE EXECUTION CONDITION SATISFIED?
NO
YES
S13
IS AT LEAST ONE OF CONDITIONS A AND C SATISFIED?
YES
NO
S14
CLEANING CONTROL PROCESSING
S15
DETECT HUMIDITY
S16
SET DETERIORATION THRESHOLD
S17
DEGREE OF DETERIORATION > DETERIORATION THRESHOLD?
YES
NO
S20
IS DENSITY ACQUISITON EXECUTION CONDITION SATISFIED?
YES
NO
S24
FORM PATTERN FOR DENSITY ACQUISITION
S25
ACQUIRE IMAGE DENSITIES OF MARKS
S26
UPDATE DENSITY CORRECTION VALUES
S21
FORM PATTERN FOR POSITION ACQUISITION
S22
ACQUIRE POSITIONS OF MARKS
S23
UPDATE POSITION CORRECTION VALUES
END

FIG. 5

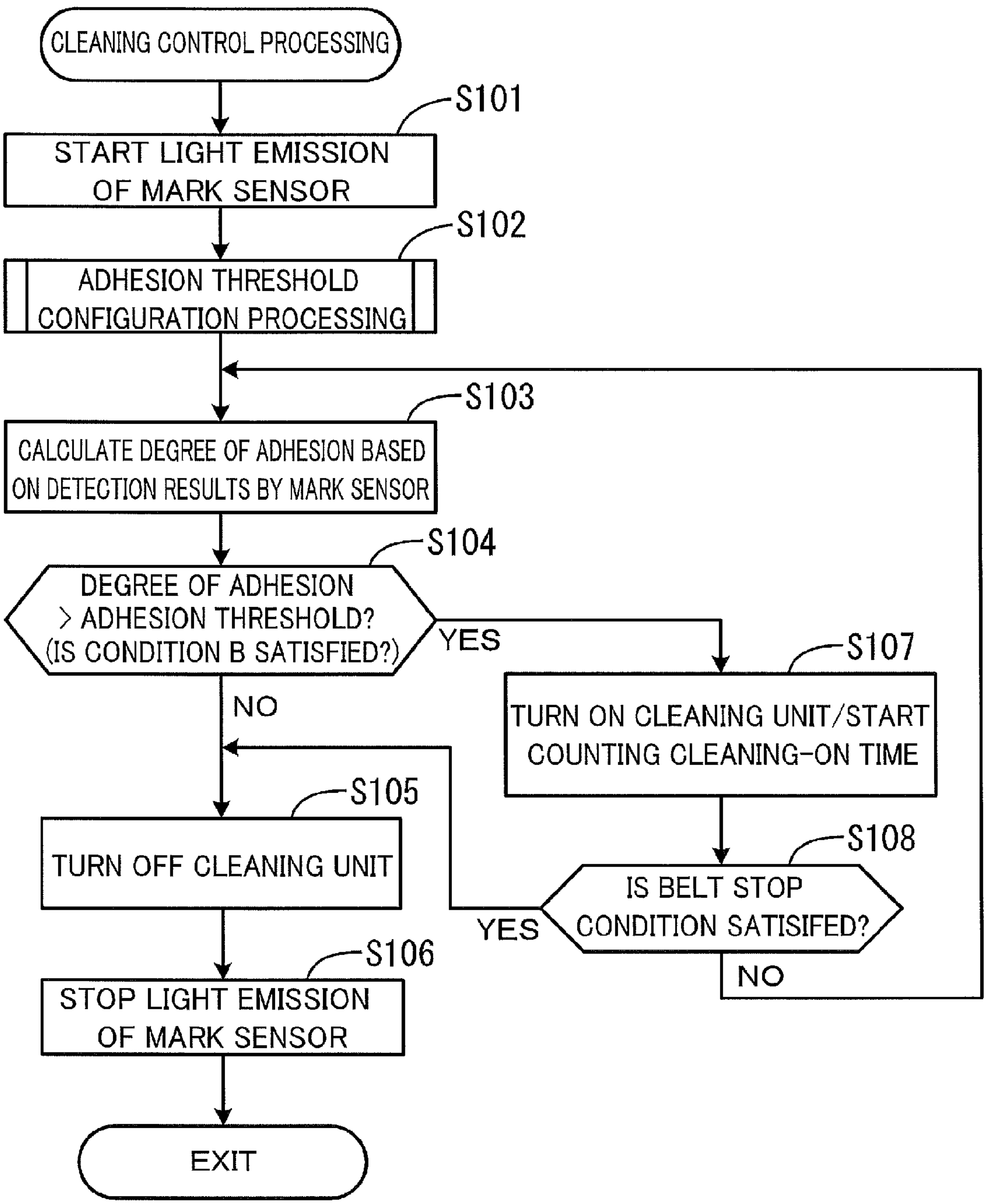

CLEANING CONTROL PROCESSING
S101
START LIGHT EMISSION OF MARK SENSOR
S102
ADHESION THRESHOLD CONFIGURATION PROCESSING
S103
CALCULATE DEGREE OF ADHESION BASED ON DETECTION RESULTS BY MARK SENSOR
S104
DEGREE OF ADHESION > ADHESION THRESHOLD? (IS CONDITION B SATISFIED?)
YES
NO
S107
TURN ON CLEANING UNIT/START COUNTING CLEANING-ON TIME
S105
TURN OFF CLEANING UNIT
S108
IS BELT STOP CONDITION SATISIFED?
YES
NO
S106
STOP LIGHT EMISSION OF MARK SENSOR
EXIT

FIG. 6

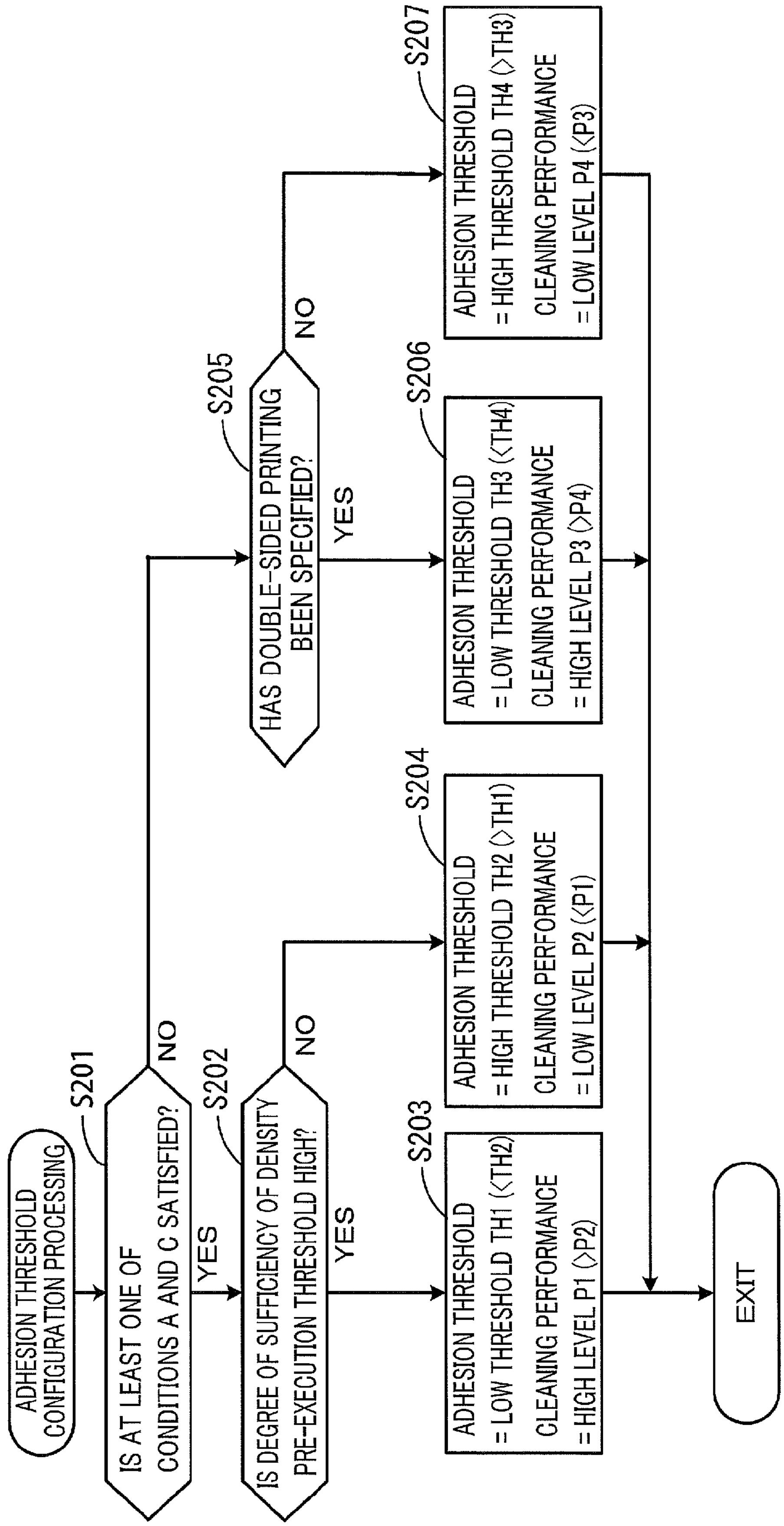

ADHESION THRESHOLD CONFIGURATION PROCESSING
S201
IS AT LEAST ONE OF CONDITIONS A AND C SATISFIED?
YES
NO
S202
IS DEGREE OF SUFFICIENCY OF DENSITY PRE-EXECUTION THRESHOLD HIGH?
YES
NO
S203
ADHESION THRESHOLD = LOW THRESHOLD TH1 (<TH2) CLEANING PERFORMANCE = HIGH LEVEL P1 (>P2)
S204
ADHESION THRESHOLD = HIGH THRESHOLD TH2 (>TH1) CLEANING PERFORMANCE = LOW LEVEL P2 (<P1)
S205
HAS DOUBLE-SIDED PRINTING BEEN SPECIFIED?
YES
NO
S206
ADHESION THRESHOLD = LOW THRESHOLD TH3 (<TH4) CLEANING PERFORMANCE = HIGH LEVEL P3 (>P4)
S207
ADHESION THRESHOLD = HIGH THRESHOLD TH4 (>TH3) CLEANING PERFORMANCE = LOW LEVEL P4 (<P3)
EXIT

FIG. 7

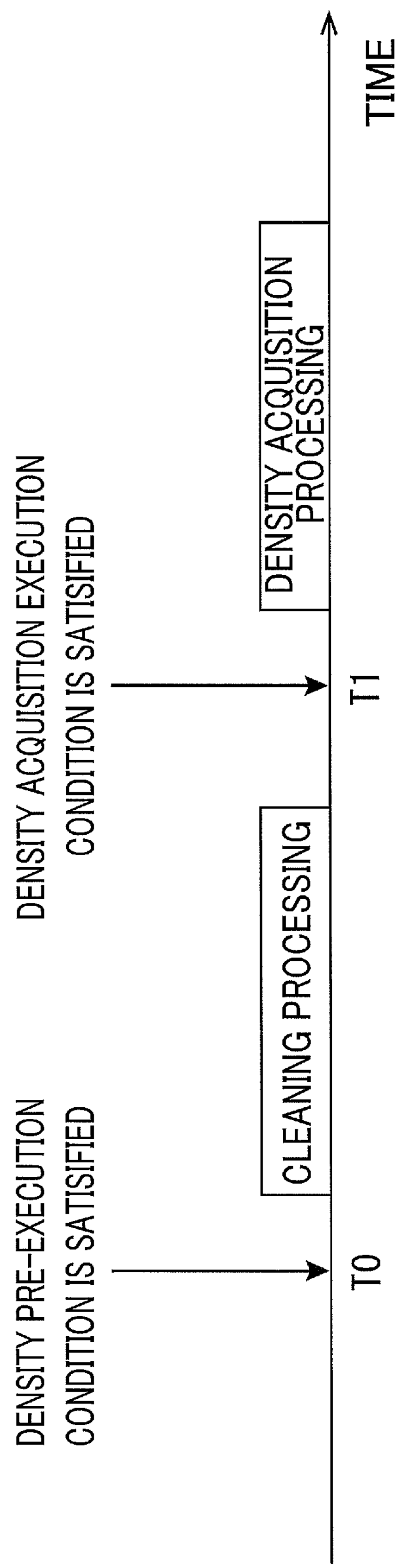

DENSITY PRE-EXECUTION CONDITION IS SATISFIED
DENSITY ACQUISITION EXECUTION CONDITION IS SATISFIED
CLEANING PROCESSING
DENSITY ACQUISITION PROCESSING
T0
T1
TIME

IMAGE FORMING APPARATUS HAVING BEARING BODY AND CLEANING UNIT

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2013-109552 filed May 24, 2013. The entire content of this priority application is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a technology for cleaning a bearing body such as a belt provided in an image forming apparatus.

BACKGROUND

There has been conventionally proposed an image forming apparatus having a function for cleaning a transfer belt. This image forming apparatus has the transfer belt, a detection sensor, and a cleaning unit. In the image forming apparatus, an image for density detection is formed on a conveyance surface of the transfer belt. Based on detection results of the density detection image by the density sensor, image density of the density detection image is acquired. Next, the cleaning unit is used to clean the conveyance surface of the transfer belt. Thereafter, based on detection results of the conveyance surface of the transfer belt by the density sensor, it is determined whether the conveyance surface of the transfer belt needs to be cleaned moreover. When it is determined that the transfer belt needs to be cleaned moreover, the cleaning unit is used again to clean the conveyance surface of the transfer belt.

SUMMARY

When a pattern image, such as the density detection image, is formed on a bearing body, such as the transfer belt, substances, such as coloring agent and fragments of sheets, may have been adhered onto the bearing body. In such a case, acquisition accuracy of the pattern image will be deteriorated.

In the above-described conventional image forming apparatus, the transfer belt is cleaned immediately after the density detection image is detected. So, substances may possibly be adhered onto the transfer belt until the density detection image is formed for the next time. In such a case, the acquisition accuracy of the density detection image will be deteriorated.

In view of the foregoing, it is an object of the invention to provide a technology that can restrain deterioration in the acquisition accuracy of a pattern image that will possibly occur due to substances adhered to the bearing body.

In order to attain the above and other objects, the invention may provide an image forming apparatus. The image forming apparatus may include: a bearing body; an image forming section; a detection unit; a cleaning unit; and a control device. The image forming section may be configured to form an image on the bearing body. The detection unit may be configured to output detection results that correspond to a state of a surface of the bearing body. The cleaning unit may be configured to clean the bearing body. The cleaning unit may be configured to be brought into a first state and a second state different from the first state. The cleaning unit in the first state may attain a first cleaning performance level. The cleaning unit in the second state may attain a second cleaning performance level that is higher than the first cleaning performance level. The control device may be configured to: execute a pre-execution condition determination to determine whether a pre-execution condition is satisfied; when it is determined that the pre-execution condition is satisfied, bring the cleaning unit from the first state into the second state and control the cleaning unit to clean the bearing body; execute an execution condition determination to determine whether an execution condition is satisfied; and when it is determined that the execution condition is satisfied, execute a pattern acquisition for forming a pattern image on the bearing body by using the image forming section and acquiring characteristics of the pattern image based on detection results that are outputted from the detection unit by detecting the pattern image. The pre-execution condition may include a condition that a correlation value satisfies a first condition. The correlation value may be correlated with an amount of deviation in characteristics of images formed by the image forming section. The execution condition may include a condition that the correlation value satisfies a second condition. The correlation value may satisfy the first condition before satisfying the second condition.

According to another aspect, the present invention may provide a method of controlling an image forming apparatus. The image forming apparatus may include: a bearing body; an image forming section configured to form an image on the bearing body; a detection unit configured to output detection results that correspond to a state of a surface of the bearing body; and a cleaning unit configured to clean the bearing body, the cleaning unit being configured to be brought into a first state and a second state different from the first state, the cleaning unit in the first state attaining a first cleaning performance level, the cleaning unit in the second state attaining a second cleaning performance level that is higher than the first cleaning performance level. The method may include: executing a pre-execution condition determination to determine whether a pre-execution condition is satisfied; when it is determined that the pre-execution condition is satisfied, bringing the cleaning unit from the first state into the second state and controlling the cleaning unit to clean the bearing body; executing an execution condition determination to determine whether an execution condition is satisfied; and when it is determined that the execution condition is satisfied, executing a pattern acquisition for forming a pattern image on the bearing body by using the image forming section and acquiring characteristics of the pattern image based on detection results that are outputted from the detection unit by detecting the pattern image. The pre-execution condition may include a condition that a correlation value satisfies a first condition. The correlation value may be correlated with an amount of deviation in characteristics of images formed by the image forming section. The execution condition may include a condition that the correlation value satisfies a second condition. The correlation value may satisfy the first condition before satisfying the second condition.

According to still another aspect, the present invention may provide a non-transitory computer readable storage medium storing a set of program instructions installed on and executed by a computer for controlling an image forming apparatus. The image forming apparatus may include: a bearing body; an image forming section configured to form an image on the bearing body; a detection unit configured to output detection results that correspond to a state of a surface of the bearing body; and a cleaning unit configured to clean the bearing body, the cleaning unit being configured to be brought into a first state and a second state different from the first state, the cleaning unit in the first state attaining a first cleaning perfor-

mance level, the cleaning unit in the second state attaining a second cleaning performance level that is higher than the first cleaning performance level. The program instructions may include: executing a pre-execution condition determination to determine whether a pre-execution condition is satisfied; when it is determined that the pre-execution condition is satisfied, bringing the cleaning unit from the first state into the second state and controlling the cleaning unit to clean the bearing body; executing an execution condition determination to determine whether an execution condition is satisfied; and when it is determined that the execution condition is satisfied, executing a pattern acquisition for forming a pattern image on the bearing body by using the image forming section and acquiring characteristics of the pattern image based on detection results that are outputted from the detection unit by detecting the pattern image. The pre-execution condition may include a condition that a correlation value satisfies a first condition. The correlation value may be correlated with an amount of deviation in characteristics of images formed by the image forming section. The execution condition may include a condition that the correlation value satisfies a second condition. The correlation value may satisfy the first condition before satisfying the second condition.

BRIEF DESCRIPTION OF THE DRAWINGS

The particular features and advantages of the invention as well as other objects will become apparent from the following description taken in connection with the accompanying drawings, in which:

FIG. **1** schematically shows the configuration of a printer according to an embodiment of the present invention;

FIG. **2** is a block diagram schematically showing an electrical structure of the printer;

FIG. **3** is a flowchart of a print control processing according to the embodiment;

FIG. **4** is a flowchart of a cleaning-and-correction control processing according to the embodiment;

FIG. **5** is a flowchart of a cleaning control processing shown in FIG. **4**;

FIG. **6** is a flowchart of an adhesion threshold configuration processing shown in FIG. **5**; and

FIG. **7** is a timing chart showing relationship between when a density pre-execution condition is satisfied and when a density acquisition execution condition is satisfied.

DETAILED DESCRIPTION

An Embodiment

A printer **1** according to an embodiment of the present invention will be described with reference to FIGS. **1** to **7**.

Directions used in the following description in relation to the printer **1** will reference the state of the printer **1** when the printer **1** is resting on a horizontal surface. More specifically, the left side in FIG. **1** will be referred to as the "front side of the printer **1**," and the upper side in FIG. **1** as the "upper side of the printer **1**," as indicated by the arrows in FIG. **1**. Further, left and right sides of the printer **1** in the following description will be based on the perspective of the user facing the front side of the printer **1**. Thus, the near side of the printer **1** in FIG. **1** will be considered the "right side of the printer **1**," as also indicated by the arrows in FIG. **1**.

The printer **1** is a direct-to-paper transfer tandem type printer. The printer **1** has a structure capable of performing both of single-sided printing and double-sided printing. The single-sided printing is for forming an image on a single surface of a sheet **3**. The double-sided printing is for forming images on both front and back surfaces of a sheet **3**. In addition, this printer **1** is capable of forming color images using toner in four colors black, yellow, magenta, and cyan. Incidentally, in order to discriminate between constituent parts of and terms related to the printer **1** in the respective colors, reference numerals for these parts and terms are suffixed with K (black), Y (yellow), M (magenta), and C (cyan).

The printer **1** is an example of an image forming apparatus. The single-sided printing is an example of single-sided image formation. The double-sided printing is an example of double-sided image formation.

(Overall Structure of Printer)

As shown in FIG. **1**, the printer **1** includes, within a casing **2**, a sheet accommodating unit **10**, a conveyance unit **20**, and an image forming section **30**.

The casing **2** is as a whole formed into a substantially box-like shape. The casing **2** has an upper surface portion into which an opening **2**A is formed. The casing **2** has a cover **2**B. The cover **2**B has a rear end side that is rotatably connected to the casing **2**. The cover **2**B can be displaced between a closed posture, thereby closing the opening **2**A (see FIG. **1**), and an open posture, thereby opening the opening **2**A. By placing the cover **2**B in the open posture, a belt unit **23** and processing units **33**K to **33**C can be replaced.

The sheet accommodating unit **10** is disposed at a bottom portion within the casing **2**. The sheet accommodating unit **10** includes a tray **11** and a push-up member **12**. The tray **11** is capable of accommodating a stack of a plurality of sheets **3** therein. The sheets **3** are, for example, sheets of paper or overhead projector sheets. The push-up member **12** is provided in the tray **11**, and is configured to push upward a front side portion of the sheets **3** accommodated in the tray **11**.

The conveyance unit **20** includes a pickup roller **21**, the belt unit **23**, discharge rollers **25**, and a reversal mechanism **26**. The pickup roller **21** is disposed upward of a front end of the tray **11**. The pickup roller **21** comes into contact with an upper surface of a frontward portion of the sheets **3** that have been pushed upward by the push-up member **12**. The pickup roller **21** is driven to rotate, thereby conveying the topmost of the sheets **3** loaded in the tray **11** one by one toward the belt unit **23**.

The belt unit **23** has a pair of supporting rollers **23**A and **23**B, and a belt **24**. The belt **24** constitutes a loop and is mounted on and around the pair of supporting rollers **23**A and **23**B in a taut state. The rearward supporting roller **23**B is driven to rotate by a drive motor **20**A (see FIG. **2**), and thereby the belt **24** rotationally moves clockwise in FIG. **1**, and conveys rearward the sheet **3** placed on an upper surface of the belt **24**. The belt **24** is an example of a bearing body and of a rotating body. The supporting roller **23**B and the drive motor **20**A are examples of a driving unit.

The belt **24** is made of polycarbonate resin material, for example. A surface of the belt **24** is subjected to mirror finishing. The belt **24** has an interior side at which are disposed four transfer rollers **34**K to **34**C. The transfer rollers **34**K to **34**C are constituents of the image forming section **30**. The respective transfer rollers **34**K to **34**C are disposed so as to oppose photosensitive bodies **40**K to **40**C of corresponding process units **33**K to **33**C, with the belt **24** interposed therebetween. The process units **33**K to **33**C will be described later

The discharge rollers **25** are disposed at the upper surface of the casing **2**. The discharge rollers **25** are capable of performing forward rotation to deliver sheets **3** conveyed from the belt **24** out toward the upper surface of the casing **2**, and of performing reverse rotation to return sheets **3** back into the casing **2** again. The reversal mechanism **26** includes multiple reverse conveying rollers **26**A disposed downward of the tray **11**. The reversal mechanism **26** conveys the sheets **3** that have been returned into the casing **2** by the reverse rotation of the discharge rollers **25**, while reversing the front and back surfaces of the sheets **3**, and delivers the sheets **3** onto the belt **24** again. In FIG. **1**, solid arrows indicate a forward conveyance path Z1 along which the sheets **3** are guided from the tray **11** via the belt **24** to the discharge rollers **25**. Dashed arrows indicate a reverse conveyance path Z2 along which the sheets **3** are guided by the reversal mechanism **26** from the discharge rollers **25** onto the belt **24**, while being reversed in their front and back surfaces.

The image forming section **30** is disposed upward of the belt unit **23**. The image forming section **30** includes four image forming units **31**K, **31**Y, **31**M, and **31**C corresponding to the respective colors black, yellow, magenta, and cyan, and a fixing unit **50**. The four image forming units **31**K, **31**Y, **31**M, and **31**C are arrayed in the conveyance direction of the belt **24**, that is, in the front-rear direction.

The four image forming units **31**K, **31**Y, **31**M, and **31**C differ only in toner color, and are otherwise identical in terms of structure and operation. The structure and operation of the image forming unit **31**K will now be described below. The image forming unit **31**K is configured to form toner images on the belt **31** or on sheets **3**. The image forming unit **31**K has an exposure unit **32**K, the process unit **33**K, and the transfer roller **34**K.

The exposure unit **32**K has multiple LEDs (not shown). These LEDs are arrayed in a single line in a left-right direction. In the printer **1**, the left-right direction is a main scanning direction, and the front-rear direction is a sub scanning direction. The exposure unit **32**K carries out exposure by having the LEDs radiate light onto a surface of the opposing photosensitive body **40**K, with light emission controlled based on image data for an image to be formed.

The process unit **33**K has a toner accommodating chamber **36**, a supply roller **37**, a developing roller **38**, and a thickness regulating blade **39**. The toner accommodating chamber **36** is configured to accommodate black toner which constitutes a coloring agent. The developing roller **28** is applied with a developing bias by an application circuit (not shown). The toner in the toner accommodating chamber **36** is supplied onto the supply roller **37**. As the toner is supplied from the supply roller **37** to the developing roller **38**, the toner is tribocharged to a positive polarity between the supply roller **37** and the developing roller **38**. The toner on the developing roller **38** is further tribocharged between the developing roller **38** and the thickness regulating blade **39**, and is regulated into a layer of uniform thickness. The printer **1** can change the developing bias, which the application circuit applies to the developing roller **38**, by changing a bias correction value as will be described later. The toner accommodating chamber **36** is an example of an accommodating part.

The process unit **33**K further has the photosensitive body **40**K and a scorotron charger **41**. The photosensitive body **40**K is covered by a photosensitive layer, whose surface has positive charging characteristics. When the printer **1** performs a print processing and various types of acquisition processings to be described later, the photosensitive body **40**K is driven to rotate, and the surface of the photosensitive body **40**K is uniformly positively charged. The positively-charged portion is then exposed by the exposure unit **32**K, as a result of which an electrostatic latent image is formed on the surface of the photosensitive body **40**K. The photosensitive body **40**K is an example of an image bearing body.

Next, the toner on the developing roller **38** is supplied to the electrostatic latent image, thereby transforming the electrostatic latent image into a visible image, and thus forming a toner image. As the sheet **3** passes through successive transfer locations between the photosensitive body **40**K and the transfer roller **34**K, the toner image carried on the surface of the photosensitive body **40**K is sequentially transferred onto the sheet **3** by a transfer voltage of negative polarity applied to the transfer roller **34**K. The sheet **3** onto which the toner image has been transferred is then conveyed to the fixing unit **50**, where the toner image is thermally fixed. The sheet **3** is then conveyed upward and discharged onto the upper surface of the casing **2**.

When double-sided printing is executed, the sheet **3** is delivered from the tray **11** onto the belt **24**, and images are formed by the image forming section **30** on the back surface of the sheet **3**, that is, the surface of the sheet **3** that faced downwardly when the sheet **3** was accommodated in the tray **11**. Thereafter, the sheet **3** is delivered to the discharge rollers **25**. Then, as a result of the reverse rotation of the discharge rollers **25**, the sheet **3** is conveyed by the reverse conveying rollers **26**A and is delivered onto the belt **24** again with the front and back surfaces thereof reversed. Images are then formed by the image forming section **30** on the front surface of the sheet **3**, that is, the surface of the sheet **3** that faced upwardly when the sheet **3** was accommodated in the tray **11**. The sheet **3** is then discharged to the upper surface of the casing **2**.

The printer **1** further includes, within the casing **2**, a cleaning unit **60**, a mark sensor **70**, and a humidity sensor **71**. The cleaning unit **60** is disposed downward of the belt unit **23**. The cleaning unit **60** serves to electrically attract and recover adhered substances such as adhered toner and paper dust that have adhered to the surface of the belt **24**. It is noted that the adhered substances include a pattern for position acquisition and a pattern for density acquisition to be described later. The cleaning unit **60** has a cleaning roller **61**, a recovery roller **62**, a backup roller **63**, a cleaning blade **64**, and a reservoir box **65**.

The cleaning roller **61** includes: a shaft member **61**A extending in the left-right direction; and a foam material made of silicone and provided on the outer periphery of the shaft member **61**A. The backup roller **63** is made of metal, and is disposed so as to oppose the cleaning roller **61** with the belt **24** interposed between the backup roller **63** and the cleaning roller **61**. The backup roller **63** is electrically connected to a ground line (not shown).

The cleaning roller **61** is driven to rotate, while being in contact with the belt **24**, so that the cleaning roller **61** moves in a direction opposite to that of the belt **24** at the area where the cleaning roller **61** contacts the belt **24**. The cleaning roller **61** is configured to be applied with a first cleaning voltage. When the first cleaning voltage applied to the cleaning roller **61** reaches a first target level, the cleaning roller **61** becomes capable of electrically attracting substances adhered to the belt **24**, thereby cleaning the surface of the belt **24**. It is noted that the polarity of the first target level is opposite to that of the toner. An example of the first target level is −1,200 volts (V).

The recovery roller **62** is made of metal. For example, the recovery roller **72** may be made of nickel-plated iron, or made of stainless steel. The recovery roller **62** is in contact with the cleaning roller **61**. The recovery roller **62** is configured to be applied with a second cleaning voltage. When the second cleaning voltage applied to the recovery roller **62** reaches a second target level, the recover roller **62** becomes capable of electrically attracting substances adhered to the cleaning roller **61**, thereby recovering the adhered substances from the cleaning roller **61**. It is also noted that polarity of the second target level is opposite to that of the toner. An example of the second target level is −1,600 volts (V).

The cleaning blade **64** is made of rubber, for example. The cleaning blade **64** is in abutment contact with the recovery roller **62**, and is configured to scrape off substances that have adhered to the recovery roller **62**. The adhered substances that are scraped off by the cleaning blade **64** are accumulated in the reservoir box **65**.

The mark sensor **70** is configured to output detection results that correspond to a state of a surface of the belt **24**. More specifically, the mark sensor **70** is an optical sensor, and includes: a light projection part **70**A for projecting light toward a detection location X defined on the surface of the belt **24**; and a light reception part **70**B for receiving light reflected from the detection location X. The state of the surface of the belt **24** changes depending on the degree of adhesion of substances on the belt **24**. The state of the surface of the belt **24** therefore changes also depending on positions and image densities of the pattern image formed on the belt **24**. The humidity sensor **71** is configured to detect humidity within the casing **2**, and to output detection results to a controller **80**. The mark sensor **70** is an example of a detection unit. The humidity sensor **71** is an example of a humidity detection unit.

Electrical Structure of Printer

As shown in FIG. **2**, the printer **1** includes the conveyance unit **20**, the image forming section **30**, the cleaning unit **60**, the mark sensor **70**, and the humidity sensor **71**, as well as the controller **80**, an operating unit **90**, a display unit **91**, and a communication unit **92**.

The controller **80** has a CPU (central processing unit) **81**, a ROM **82**, a RAM **83**, an ASIC (Application Specific Integrated Circuit) **84**, and a nonvolatile memory **85**. The ROM **82** stores programs for executing a print control processing and a cleaning-and-correction control processing according to the present embodiment to be described later, and programs for performing other various operations of the printer **1**. The CPU **81** controls various parts of the printer **1** in accordance with programs read from the ROM **82** into the RAM **83**. Instead of being stored in the ROM **82**, the programs may be stored in a nonvolatile memory such as a CD-ROM, a hard disk device, or a flash memory. The ASIC **84** is a hardware circuit such as a dedicated image processing circuit. The nonvolatile memory **85** stores a position execution threshold αth and a density execution threshold βth, which will be described later.

The operating unit **90** is equipped with various buttons. The operating unit **90** is configured to allow a variety of input operations to be performed by a user. The operating unit **90** is configured to send to the controller **80** operating signals that correspond to the input operations of the user. The display unit **91** is provided with a liquid crystal display and various lights. The display unit **91** is configured to display a variety of configuration screens and operating states of the printer **1**. The communication unit **92** is configured to perform mutual data communication with external information processing devices (not shown), such as personal computers, over wired or wireless communication lines. The operating unit **90** and the communication unit **92** are examples of a reception unit.

Various Types of Pattern Acquisition Processing, and Execution and Pre-Execution Conditions

The controller **80** executes a position acquisition processing and a density acquisition processing, as described below.

(1) Position Acquisition Processing

A position acquisition execution condition is set for the printer **1**. That is, the printer **1** is configured to execute the position acquisition processing when the printer **1** satisfies the position acquisition execution condition. In the position acquisition processing, the printer **1** forms a prescribed pattern for position acquisition (not shown) on the belt **24** by using the image forming section **30**. The printer **1** acquires positions in the sub scanning direction of respective marks constituting the position acquisition pattern (which will be referred to simply as image forming positions) based on detection results which the mark sensor **70** has outputted by detecting the position acquisition pattern. The position acquisition processing is an example of a pattern acquisition, and the positions in the sub scanning direction of the marks constituting the position acquisition pattern are an example of characteristics of a pattern image.

The printer **1** needs to satisfy the position acquisition execution condition, in order to execute the position acquisition processing. The position acquisition execution condition includes such a condition that a position correlation value becomes greater than or equal to a position execution threshold. The position correlation value is correlated with an amount of deviation in positions of images formed by the image forming section **30** relative to ideal positions. In this example, the printer **1** satisfies the position acquisition execution condition if the printer **1** satisfies such a condition that a total sheet count α has become greater than or equal to a position execution threshold αth. The total sheet count α is the number of sheets **3** on which printing has been performed since the last time that the position acquisition processing was carried out. In other words, the total sheet count α is the number of printed sheets **3** that has been counted since the last time that the position acquisition processing was carried out. The total sheet count α will be referred to simply as printed sheet count α hereinafter. The printed sheet count α and the position execution threshold αth are stored in the nonvolatile memory **85**. The position acquisition execution condition is an example of an execution condition. The printed sheet count α is an example of a correlation value and of a position correlation value, and the position execution threshold αth is an example of an execution threshold and of a position execution threshold.

A position pre-execution condition is also set for the printer **1**. The printer **1** satisfies the position pre-execution condition earlier than the printer **1** satisfies the position acquisition execution condition. In this example, the printer **1** satisfies the position pre-execution condition if the printer **1** satisfies both of the following conditions A and B:

Condition A: That the printed sheet count α becomes greater than or equal to a position pre-execution threshold αths, which is smaller than the position execution threshold αth. In this example, the position pre-execution threshold αths has such a value that is obtained by multiplying the position execution threshold αth by a coefficient which is smaller than 1. The coefficient is preferably larger than 0.5. In this example, the coefficient is equal to 0.8. Or, the position pre-execution threshold αths may be obtained by subtracting a prescribed value from the position execution threshold αth.

Condition B: That a degree of adhesion of substances on the belt **24** exceeds an adhesion threshold, which will be described later.

The position pre-execution condition is an example of a pre-execution condition. The position pre-execution threshold αths is an example of a pre-execution threshold and of a position pre-execution threshold.

(2) Density Acquisition Processing

A density acquisition execution condition is also set for the printer **1**. The printer **1** is configured to execute the density acquisition processing when the printer **1** satisfies the density acquisition execution condition. In the density acquisition processing, the printer **1** forms a prescribed pattern for density acquisition (not shown) on the belt **24** by using the image forming section **30**. The printer **1** acquires image densities of respective marks constituting the density acquisition pattern (which will be referred to simply as image densities) based on detection results which the mark sensor **70** has outputted by detecting the density acquisition pattern. The density acquisition processing is an example of a pattern acquisition, and the image densities of the marks constituting the density acquisition pattern are an example of characteristics of a pattern image.

The printer **1** needs to satisfy the density acquisition execution condition, in order to execute the density acquisition processing. The density acquisition execution condition includes such a condition that a density correlation value becomes greater than or equal to a density execution threshold. The density correlation value is correlated with an amount of deviation in image densities of images formed by the image forming section **30** relative to ideal image densities. In this example, the printer **1** satisfies the density acquisition execution condition if the printer **1** satisfies such a condition that a humidity β detected by the humidity sensor **71** has become higher than or equal to a density execution threshold βth. The humidity β and the density execution threshold βth are stored in the nonvolatile memory **85**. The density acquisition execution condition is an example of an execution condition. The humidity β is an example of a correlation value and of a density correlation value, and the density execution threshold βth is an example of an execution threshold and of a density execution threshold.

A density pre-execution condition is also set for the printer **1**. The printer **1** satisfies the density pre-execution condition earlier than the printer **1** satisfies the density acquisition execution condition. In this example, the printer **1** satisfies the density pre-execution condition if the printer **1** satisfies both of the following condition C and the condition B described above.

Condition C: That the humidity β becomes higher than or equal to a density pre-execution threshold βths, which is lower than the density execution threshold βth. In this example, the density pre-execution threshold βths has such a value that is obtained by multiplying the density execution threshold βth by a coefficient which is smaller than 1. The coefficient is preferably larger than 0.5. In this example, the coefficient is equal to 0.8. Or, the density pre-execution threshold βths may be obtained by subtracting a prescribed value from the density execution threshold βth.

The density pre-execution condition is an example of a pre-execution condition. The density pre-execution threshold βths is an example of a pre-execution threshold and of a density pre-execution threshold.

Print Control Processing

When the printer **1** is powered on, the controller **80** executes print control processing shown in FIG. **3** repeatedly at prescribed time intervals.

First, in S**1** the CPU **81** determines whether or not the operating unit **90** or the communication unit **92** has received a print command. Print commands include print data for images specified by the user, and print conditions information such as whether to perform single-side or double-sided printing. The CPU **81** is capable of determining, based on the operating signals from the operating unit **90**, whether or not the operating unit **90** received a print command as a result of user input operations. The CPU **81** is also capable of determining, based on the signals from the communication unit **92**, whether or not the communication unit **92** received a print command from an information processing device. Print commands are an example of formation commands.

If the CPU **81** determines that a print command has not been received (S**1**: NO), the CPU **81** terminates the print control processing, and starts print control processing again after a prescribed period of time has passed. On the other hand, if the CPU **81** determines that a print command has been received (S**1**: YES), in S**2** the CPU **81** causes the belt **24** to start being driven to rotate. In addition, in S**2** the CPU **81** starts to count the number of rotations of the belt **24**, in order to determine the total number of rotations that have occurred since the printer **1** was new, that is, since the printer **1** was shipped. The CPU **81** is capable of counting the number of rotations of the belt **24** based on a length of time during which the drive motor **20**A is driving. The printer **1** may be provided with a rotation count sensor (not shown) for detecting the number of rotations of the belt **24**. In such a case, the CPU **81** may count the number of rotations of the belt **24** based on the detection results of the rotation count sensor.

When sheets **3** are conveyed onto the belt **24**, in S**3** the CPU **81** executes print processing to print images on the sheets **3** based on the print data contained in the print command. In addition, in S**3** the CPU **81** counts the number of sheets **3** that have been printed over the course of this print processing, and adds this counted result to the printed sheet count α.

If single-sided printing is specified in the print conditions information, the CPU **81** causes the image forming section **30** to execute single-sided printing. On the other hand, if double-sided printing is specified in the print conditions information, the CPU **81** causes the image forming section **30** to execute double-sided printing. When the print processing has completed, the CPU **81** stops the belt **24** from being driven to rotate in S**4**, and terminates this print control processing. The CPU **81** starts the print control processing again after a prescribed time period has passed. The processing in S**2** and S**3** is an example of image formation.

Cleaning-and-Correction Control Processing

When the printer **1** is powered on, the controller **80** also executes a cleaning-and-correction control processing shown in FIG. **4** repeatedly at prescribed time intervals. Thus, the controller **80** executes the cleaning-and-correction control processing in parallel with the print control processing. By executing the cleaning-and-correction control processing, the cleaning unit **60** can clean the belt **24** in advance, that is, before the printer **1** satisfies the position acquisition execution condition or the density acquisition execution condition. This can prevent the accuracy in acquisition of pattern images from degrading due to substances adhered on the belt **24** during position acquisition processing or density acquisition processing.

Specifically, the CPU **81** first determines in S**11** whether or not a belt drive condition is satisfied. The belt drive condition is a condition that the printer **1** needs to satisfy in order to start driving the belt **24** to rotate. In this example, the belt drive condition is that the operating unit **90** or the communication unit **92** has received a print command. It is noted that when a print command has been received, the CPU **81** causes the belt **24** to start being driven to rotate in S**2** to form images on the sheets **3** based on the print command. If the CPU **81** determines that the belt drive condition has not been satisfied (S**11**: NO), the CPU **81** terminates this cleaning-and-correction control processing. Then, the CPU **81** starts the cleaning-and-correction control processing again after a prescribed period of time has passed. On the other hand, if the CPU **81** determines that the belt drive condition has been satisfied (S**11**: YES), in S**12** the CPU **81** determines whether or not at least one of the position acquisition execution condition and the density acquisition execution condition is satisfied.

(1) If Neither the Position Acquisition Execution Condition Nor the Density Acquisition Execution Condition is Satisfied

If the CPU **81** determines that neither the position acquisition execution condition nor the density acquisition execution condition is satisfied (S**12**: NO), the CPU **81** next determines in S**13** whether or not at least one of the conditions A and C is satisfied. As described already, the condition A is part of the position pre-execution condition, and is a condition that the printed sheet count α becomes greater than or equal to the position pre-execution threshold αths. The condition C is part of the density pre-execution condition, and is a condition that the humidity β becomes greater than or equal to the density pre-execution threshold βths. In this way, the CPU **81** determines whether or not at least one from among: the part of the position pre-execution condition; and the part of the density pre-execution condition, is satisfied. Specifically, the CPU **81** determines in S**13** whether at least one of the printed sheet count α and the humidity β becomes greater than or equal to the corresponding pre-execution threshold αths or βths. The processing in S**13** is an example of pre-execution condition determination.

(1-1) If at Least One of Conditions a and C is Satisfied

If condition A is satisfied, this signifies that the time to execute the position acquisition processing is approaching, and that the need has arisen to clean the belt **24** beforehand in order to prevent degradation of the accuracy in position acquisition. If condition C is satisfied, this signifies that the time to execute the density acquisition processing is approaching, and that the need has arisen to clean the belt **24** beforehand in order to prevent degradation of the accuracy in density acquisition.

(1-1-1) Cleaning Control Processing

If the CPU **81** determines that at least one of the conditions A and C is satisfied (S**13**: YES), in S**14** the CPU **81** executes a cleaning control processing shown in FIG. **5**. In the cleaning control processing, the printer **1** detects the degree of adhesion of substances on the belt **24**, in other words how dirty the belt **24** is. The printer **1** then determines, based on the detection results, whether or not the belt **24** should currently be cleaned.

More specifically, in S**101**, the CPU **81** first controls the light projection part **70**A of the mark sensor **70** to start emitting light. Then, in S**102**, the CPU **81** executes a threshold configuration processing to set the adhesion threshold as shown in FIG. **6**. The threshold configuration processing will be described later in greater detail.

Next, in S**103** the CPU **81** calculates the degree of adhesion based on the amount of light received by the light reception part **70**B of the mark sensor **70**. It is noted that there is a correlation between the degree of adhesion on the belt **24** and the amount of light received by the light reception part **70**B. It is now assumed that as the degree of adhesion of substances on the belt **24** increases, the amount of light received by the light reception part **70**B decreases. The CPU **81** can therefore calculate the degree of adhesion based on the amount of light received by the light reception part **70**B. In this example, the degree of adhesion is defined by a ratio of the amount of light currently received, with respect to the amount of light that was received when the belt **24** was new. The processing in S**103** is an example of detection.

It is noted that the CPU **81** may determine the degree of adhesion based on the amount of light reflected from a single location on the belt **24**. However, in order to detect the degree of adhesion on the entire belt **24** with a higher degree of precision, it is preferable for the CPU **81** to determine the degree of adhesion based on the amounts of light reflected from multiple locations on the belt **24**. That is, the CPU **81** may determine the degree of adhesion based on: an average value; a maximum value; or an intermediate value between the maximum value and a minimum value, of the amounts of light that have been reflected from the multiple locations on the belt **24**. Alternatively, the CPU **81** may determine the degree of adhesion based on the amounts of light that have been received from the belt **24** during a time period in which the belt **24** rotates a prescribed amount, such as a single rotation. That is, the CPU **81** may determine the degree of adhesion based on: an average value; a maximum value; or an intermediate value between the maximum value and a minimum value, of the amounts of light that have been received during the time period.

In S**104**, the CPU **81** determines whether or not the calculated degree of adhesion exceeds the adhesion threshold that has been set in S**102**. In other words, in S**104**, the CPU **81** determines whether the condition B is satisfied. The condition B is remaining part of the position pre-execution condition that is other than the condition A. The condition B is also remaining part of the density pre-execution condition that is other than the condition C. It is noted that the adhesion threshold is such a value that is no higher than a prescribed highest allowable adhesion degree. The highest allowable adhesion degree is a prescribed highest value among all the degrees of adhesion that do not substantially affect the position acquisition processing or the density acquisition processing. The processing in S**104** is an example of pre-execution condition determination. The adhesion threshold is an example of a reference adhesion degree.

If the CPU **81** determines that the calculated degree of adhesion exceeds the adhesion threshold (S**104**: YES), in S**107** the CPU **81** turns on the cleaning unit **60** by applying to the cleaning roller **61** the first cleaning voltage of the first target level and applying to the recovery roller **62** the second cleaning voltage of the second target level. It is noted that before the processing of S**107** is executed, the cleaning roller **61** and the recovery roller **62** are applied with no electric voltage. Thus, in S**107**, the CPU **81** brings the cleaning unit **60** from the state, in which the cleaning unit **60** is unable to electrically recover the adhered substances from the belt **24**, into another state, in which the cleaning unit **60** is able to electrically recover the adhered substances from the belt **24**. In this way, in S**107**, cleaning performance of the cleaning unit **60** is enhanced to such a level that is higher than a level that the cleaning unit **60** possessed before the belt **24** started to be driven to rotate.

In addition, in S**107** the CPU **81** starts tracking or measuring the length of time during which the cleaning unit **60** has been turned on, in order to determine the total length of time during which the cleaning unit **60** has been turned on since the printer **1** was new, that is, since the printer **1** was shipped. This total time is referred to simply as the cleaning-on time. The processing in S**107** is an example of cleaning.

After the cleaning unit **60** is turned on in S**107**, the CPU **81** determines in S**108** whether or not a belt stop condition is satisfied. The belt stop condition is a condition that the printer **1** needs to satisfy in order to stop driving the belt **24** to rotate. In this example, the belt stop condition is that the print processing in S3 in FIG. **3** has completed. If the CPU **81** determines that the belt stop condition has not been satisfied (S**108**: NO), this means that the belt **24** is continuing to be driven to rotate, so the CPU **81** returns to S**103**. If the CPU **81** then determines that the calculated degree of adhesion does not exceed the adhesion threshold (S**104**: NO), in S**105** the CPU **81** turns off the cleaning unit **60** by stopping application of the first and second cleaning voltages to the cleaning roller **61** and recovery roller **62**. In other words, the CPU **81** brings the cleaning unit **60** into a state in which the cleaning unit **60** is unable to electrically recover the adhered substances from the belt **24**. In this way, as long as the belt **24** is rotating, the CPU **81** keeps the cleaning unit **60** turned on until the degree of adhesion becomes lower than or equal to the adhesion threshold.

On the other hand, if the CPU **81** determines that the belt stop condition is satisfied (S**108**: YES), in S**105** the CPU **91** turns off the cleaning unit **60**. In this way, when the rotation of the belt **24** has been stopped, the CPU **81** turns off the cleaning unit **60** even if the degree of adhesion has not become smaller than or equal to the adhesion threshold. The cleaning unit **60** is kept turned on only while the belt **24** is rotating for the purpose of the print processing.

The above-described configuration can avoid driving the belt **24** to rotate for the sole purpose of cleaning. It is conceivable to drive the belt **24** to rotate for the sole purpose of cleaning. In comparison with this conceivable configuration, the configuration of the present embodiment can reduce such opportunities that the belt **24** and the cleaning roller **61** rub against each other. The configuration of the present embodiment can therefore restrain deterioration of both of the belt **24** and the cleaning roller **61**.

Even if at least one of the conditions A and C is satisfied (S**13**: YES), if the condition B is not satisfied (S**104**: NO), then this means ultimately that neither the position pre-execution condition (A plus B) nor the density pre-execution condition (C plus B) is satisfied. Accordingly, the CPU **81** proceeds to S**106** with the cleaning unit **60** kept turned off. This configuration can prevent the cleaning unit **60** from performing cleaning unnecessarily when the degree of adhesion on the belt **24** is low. This configuration can therefore restrain deterioration of the cleaning unit **60**.

In S**106**, the CPU **81** stops the light projection part **70**A from emitting light, and terminates the cleaning control processing and the cleaning-and-correction control processing. In the above-described configuration, the light projection part **70**A is controlled to emit light only while the cleaning control processing is executed. However, the light projection part **70**A may be configured to emit light continuously at all the time. That is, the light projection part **70**A may be configured to emit light not only while the cleaning control processing is executed but also while the cleaning control processing is not executed. However, deterioration of the light projection part **70**A can be prevented by controlling the light projection part **70**A to emit light only while the cleaning control processing is executed.

(1-1-2) Adhesion Threshold Configuration Processing

The adhesion threshold configuration processing of S**102** is for configuring or setting the adhesion threshold that is used in S**104**. Specifically, as shown in FIG. **6**, the CPU **81** first determines in S**201** whether or not at least one of the conditions A and C is satisfied. Specifically, the CPU **81** determines in S**201** whether at least one of the printed sheet count α and the humidity β becomes greater than or equal to the corresponding pre-execution threshold αths or βths. If the CPU **81** determines that at least one of the conditions A and C is satisfied (S**201**: YES), the CPU **81** then determines in S**202** whether or not a degree of sufficiency of the density pre-execution threshold is higher than a degree of sufficiency of the position pre-execution threshold. In other words, the CPU **81** determines whether the need to execute density acquisition processing is greater than the need to execute position acquisition processing. The degree of sufficiency of the density pre-execution threshold will be referred to simply as "density-related sufficiency degree" hereinafter. The degree of sufficiency of the position pre-execution threshold will be referred to simply as "position-related sufficiency degree" hereinafter.

The density-related sufficiency degree is defined as a relative amount of the humidity β with respect to the density pre-execution threshold βths. It is noted that the humidity β is correlated with the density deviation of images formed by the image forming section **30**. More specifically, the density-related sufficiency degree may be defined as a sufficiency ratio obtained by dividing the humidity β by the density pre-execution threshold βths ($=\beta/\beta$ths), or as a sufficiency difference obtained by subtracting the density pre-execution threshold βths from the humidity β ($=\beta-\beta$ths). It is noted that the density-related sufficiency degree being high indicates that execution of density acquisition processing is highly necessary.

The position-related sufficiency degree is defined as a relative amount of the printed sheet count α with respect to the position pre-execution threshold αths. It is noted that the printed sheet count α is correlated with the position deviation of images formed by the image forming section **30**. More specifically, the position-related sufficiency degree may be defined as a sufficiency ratio obtained by dividing the printed sheet count α by the position pre-execution threshold αths ($=\alpha/\alpha$ths), or as a sufficiency difference obtained by subtracting the position pre-execution threshold αths from the printed sheet count α ($=\alpha-\alpha$ths). It is noted that the position-related sufficiency degree being high indicates that execution of position acquisition processing is highly necessary.

If the CPU **81** determines that the density-related sufficiency degree is higher than the position-related sufficiency degree (S**202**: YES), in S**203** the CPU **81** sets the adhesion threshold to a low threshold TH1. It is noted that the low threshold TH1 is lower than the highest allowable adhesion degree. Also in S**203** the CPU **81** sets to a high level P1 the cleaning performance level to which the cleaning performance of the cleaning unit **60** should be enhanced in S**107**. The high level P1 is higher than the cleaning performance level that the cleaning unit **60** possessed before the belt **24** started to be driven to rotate. Specifically, the CPU **81** sets the absolute values of the first and second target levels to relatively high values that can enable the cleaning unit **60** to attain the cleaning performance of high level P1.

Conversely, if the CPU **81** determines that the density-related sufficiency degree is not higher than the position-related sufficiency degree (S**202**: NO), in S**204** the CPU **81** sets the adhesion threshold to a high threshold TH2 that is higher than the low threshold described above (TH2>TH1). It is noted that the high threshold TH2 is also lower than the highest allowable adhesion degree. Also in S**204** the CPU **81** sets to a low level P2 the cleaning performance level to which the cleaning performance of the cleaning unit **60** should be enhanced in S**107**. The low level P2 is lower than the high level P1 (P2<P1), but is still higher than the cleaning performance level that the cleaning unit **60** possessed before the belt **24** started to be driven to rotate. Specifically, the CPU **81** sets the absolute values of the first and second target levels to such values that can enable the cleaning unit **60** to attain the cleaning performance of low level P2. It is noted that the absolute values of the first and second target levels necessary to attain the cleaning performance of low level P2, are respectively smaller than the absolute values of the first and second target levels necessary to attain the cleaning performance of high level P1.

In general, the acquisition accuracy of image densities is more strongly affected by substances adhered onto the belt **24** than is the acquisition accuracy of image positions. That is, normally, toner adheres thinly over the entire belt **24**, and the absolute value of the amount of light received by the light receiving part **70**B of the mark sensor **70** varies accordingly. The position acquisition processing involves for example detecting both ends of a mark in the direction of motion of the belt **24**, and taking the position in the center of those ends to be the position of the mark (position detection operation). For this reason, provided that the ends of the mark can be detected, the effects due to variations in the absolute value of the amount of light received are relatively small. In contrast, image densities vary directly in accordance with the amount of light received, and thus the effects due to variations in the absolute value of the amount of light received are relatively large.

In light of this, the CPU **81** sets the adhesion threshold for the case where the density-related sufficiency degree is higher than the position-related sufficiency degree, to be lower than that for the case where the position-related sufficiency degree is higher than the density-related sufficiency degree. As a result, when there is a great need to execute density acquisition processing, the belt **24** will be cleaned by the cleaning unit **60** even if the degree of adhesion of substances on the belt **24** is relatively low. It is noted that another configuration is conceivable in which the adhesion threshold is uniform regardless of the relative magnitudes of the density-related sufficiency degree and the position-related sufficiency degree. In comparison with this comparative configuration, the configuration of the present embodiment can prevent the acquisition accuracy of image densities from being degraded due to substances adhered to the belt **24**.

In addition, the CPU **81** sets the cleaning performance for the case where the density-related sufficiency degree is higher than the position-related sufficiency degree, to be higher than that for the case where the position-related sufficiency degree is higher than the density-related sufficiency degree. It is noted that another configuration is conceivable in which the cleaning performance is enhanced to the same level regardless of the position-related sufficiency degree and the density-related sufficiency degree. In comparison with this conceivable configuration, the configuration of the present embodiment can clean the belt **24** with an appropriate cleaning performance that is not excessive nor insufficient.

If the CPU **81** determines that neither condition A nor C is satisfied (S**201**: NO), in S**205** the CPU **81** then determines, based on the print conditions information contained in the print command, whether or not double-sided printing has been specified. If the CPU **81** determines that double-sided printing has been specified (S**205**: YES), in S**206** the CPU **81** sets the adhesion threshold to a low threshold TH3. It is noted that the low threshold TH3 is also lower than the highest allowable adhesion degree. Also in S**206** the CPU **81** sets to a high level P3 the cleaning performance level to which the cleaning performance of the cleaning unit **60** should be enhanced in S**107**. The high level P3 is higher than the cleaning performance level that the cleaning unit **60** possessed before the belt **24** started to be driven to rotate. Specifically, the CPU **81** sets the absolute values of the first and second target levels to relatively high values that can enable the cleaning unit **60** to attain the cleaning performance of high level P3. The low threshold TH3 may be the same as or different from the low threshold TH1. The high level P3 may be the same as or different from the high level P1.

Conversely, if the CPU **81** determines that double-sided printing has been not specified, i.e. that single-sided printing has been specified (S**205**: NO), in S**207** the CPU **81** sets the adhesion threshold to a high threshold TH4 that is higher than the low threshold (TH4>TH3). It is noted that the high threshold TH3 is also lower than the highest allowable adhesion degree. Also in S**207** the CPU **81** sets to a low level P4 the cleaning performance level to which the cleaning performance of the cleaning unit **60** should be enhanced in S**107**. The low level P4 is lower than the high level P3 (P4<P3), but is still higher than the cleaning performance level that the cleaning unit **60** possessed before the belt **24** started to be driven to rotate. Specifically, the CPU **81** sets the absolute values of the first and second target levels to such values that can enable the cleaning unit **60** to attain the cleaning performance of low level P4. It is noted that the absolute values of the first and second target levels necessary to attain the cleaning performance of low level P4, are respectively smaller than the absolute values of the first and second target levels necessary to attain the cleaning performance of high level P3. The high threshold TH4 may be the same as or different from the low threshold TH2. The low level P4 may be the same as or different from the low level P2. After executing one of the steps from S**203** to S**207**, the CPU **81** terminates the adhesion threshold configuration processing and proceeds to S**103** in FIG. **5**.

In double-sided printing, after an image has been formed on a first side of a sheet **3** and while an image is being formed on a second side, the first side of the sheet **3** faces downward and contacts with the belt **24**. For this reason, so-called back surface stain may occur, in which substances adhered on the belt **24** have an adverse effect on the image formed on the first side. In light of this, the CPU **81** sets the adhesion threshold for the case where double-sided printing has been specified, to be lower than that for the case where single-sided printing has been specified. As a result, if double-sided printing has been specified, the belt **24** will be cleaned by the cleaning unit **60** even if the degree of adhesion of substances on the belt **24** is relatively low. In addition, the CPU **81** sets cleaning performance for the case where double-sided printing has been specified, to be higher than that for the case where single-sided printing has been specified. This configuration can prevent back surface stain from occurring during double-side printing.

(1-2) If Neither Condition A Nor C is Satisfied

In FIG. **4**, if the CPU **81** determines that neither condition A nor C is satisfied (S**13**: NO), this signifies that the need to execute position acquisition processing and density acquisition processing is low. It is noted, however, that if a degree of deterioration of the cleaning unit **60** is relatively high, when the cleaning unit **60** is turned on later in S**107**, the cleaning performance of the cleaning unit **60** will be too low to clean the belt **24** sufficiently.

In light of this, if the CPU **81** determines that neither condition A nor C is satisfied (S**13**: NO), the CPU **81** acquires in S**15** the current humidity β based on the detection results of the humidity sensor **71**. The CPU **81** sets a deterioration threshold in S**16**. The CPU **81** then determines in S**17** whether or not the degree of deterioration in the cleaning unit **60** exceeds the deterioration threshold. It is noted that the cleaning unit **60** progressively deteriorates as the total number of rotations of the cleaning roller **61**, which have occurred since the printer **1** was new, increases, or as the cleaning-on time, which has been tracked since the printer **1** was new, increases. Consequently, the degree of deterioration of the cleaning unit **60** can be calculated based on: the number of rotations of the cleaning roller **61** that have occurred since the printer **1** was new; or the cleaning-on time of the cleaning roller **61** that has been measured since the printer **1** was new. The processing in S**17** is an example of deterioration determination.

In this example, the CPU **81** calculates the degree of deterioration in the cleaning unit **60** based on the number of rotations of the belt **24** counted in S**2**, or on the cleaning-on time tracked in S**107**. It is noted that in the printer **1**, the belt **24** and the cleaning roller **61** are in continuously contact with each other. Accordingly, there is a correlation between the number of rotations of the belt **24** and the number of rotations of the cleaning roller **61**.

If the CPU **81** determines that the degree of deterioration of the cleaning unit **60** does not exceed the deterioration threshold (S**17**: NO), the CPU **81** terminates the cleaning-and-correction control processing without executing the cleaning control processing.

If, on the other hand, the CPU **81** determines that the degree of deterioration of the cleaning unit **60** exceeds the deterioration threshold (S**17**: YES), the CPU **81** executes the cleaning control processing in S**14** even though the need to execute the position acquisition processing or the density acquisition processing is low. As a result, even though the pre-execution condition is not yet satisfied (no in S**13**), if the degree of adhesion on the belt **24** exceeds the adhesion threshold (S**104**: YES), the cleaning unit **60** is turned on in S**107** to clean the belt **24**. This processing in S**107** is an example of deterioration-time cleaning.

The amount of substances that the cleaning unit **60** can remove from one circumferential length of the belt **24** decreases due to the deterioration of the cleaning unit **60**. In light of this, the configuration of the present embodiment enables the cleaning unit **60** to clean the belt **24** before the pre-execution condition is satisfied. So, it can be expected that even though the degree of deterioration in the cleaning unit **60** has already exceeded the deterioration threshold, the cleaning results that can be achieved by this cleaning unit **60** are equivalent to those that were achieved by the cleaning unit **60** when the degree of deterioration did not exceed the deterioration threshold. It is noted that another configuration is conceivable in which even though the degree of deterioration in the cleaning unit **60** exceeds the deterioration threshold, the belt **24** is not cleaned until the pre-execution condition is satisfied. In comparison with the conceivable configuration, the configuration of the embodiment can prevent the cleaning unit **60** from failing to remove adhered substances from the belt sufficiently.

It is noted that in S**16** the CPU **81** sets the deterioration threshold such that the deterioration threshold decreases as the current humidity β decreases.

In general, if humidity becomes low, fluidity of toner increases. As a result, toner more readily leaks from the toner accommodating chamber **36**, and substances more readily adhere to the belt **24**. In light of this, the CPU **81** sets the deterioration threshold such that the lower the current humidity β, the lower the deterioration threshold. With this configuration, if toner leaks from the toner accommodating chamber **36** and the quantity of substances adhering to the belt **24** increases, the belt **24** is cleaned before the pre-execution condition is satisfied. Accordingly, it can be expected that even though the degree of deterioration in the cleaning unit **60** has already exceeded the deterioration threshold, the cleaning results that can be achieved by this cleaning unit **60** are equivalent to those that were achieved by the cleaning unit **60** when the degree of deterioration did not exceed the deterioration threshold.

Or, the CPU **81** may set in S**16** the deterioration threshold such that the deterioration threshold decreases as the number of rotations of the belt **24**, which have occurred since the cleaning unit **60** was last turned off, increases. It is noted that as the number of rotations of the photosensitive bodies **40** increases, the process unit **33** deteriorates. As a result, toner more readily leaks from the toner accommodating chamber **36**, and substances more readily adhere to the belt **24**. It is noted that in the printer **1**, the photosensitive bodies **40** are in continuously contact with the belt **24**, so there is a correlation between the number of rotations of the photosensitive bodies **40** and the number of rotations of the belt **24**. In light of this, the CPU **81** may set the deterioration threshold such that the deterioration threshold decreases as the number of rotations of the belt **24** which have occurred since the cleaning unit **60** was last turned off increases. It can therefore be said that the CPU **81** may set the deterioration threshold such that the deterioration threshold decreases as the number of rotations of the photosensitive bodies **40** which have occurred since the cleaning unit **60** was last turned off increases.

With this configuration, if toner leaks from the toner accommodating chamber **36** due to deterioration of the process unit **33**, and a larger quantity of substances adheres to the belt **24**, the belt **24** is cleaned before the pre-execution condition is satisfied. Accordingly, it can be expected that even though the degree of deterioration in the cleaning unit **60** has already exceeded the deterioration threshold, the cleaning results that can be achieved by this cleaning unit **60** are equivalent to those that were achieved by the cleaning unit **60** when the degree of deterioration did not exceed the deterioration threshold. The time at which the cleaning unit **60** was last turned off is an example of a reference time.

(2) If at Least One of the Position Acquisition Execution Condition and Density Acquisition Execution Condition is Satisfied

If the CPU **81** determines that at least one of the position acquisition execution condition and density acquisition execution condition is satisfied (S**12**: YES), the CPU **81** determines in S**20** whether or not the density acquisition execution condition is satisfied.

(2-1) Position Acquisition Processing

If the CPU **81** determines that the density acquisition execution condition is not satisfied, i.e. that the position acquisition execution condition is satisfied (S**20**: NO), in S**21** and S**22** the CPU **81** executes the position acquisition processing. That is, in S**21** the CPU **81** causes the image forming section **30** to form the pattern for position acquisition on the belt **24**. More specifically, the CPU **81** reads position correction values and density correction values, which have been set most recently and are stored in the nonvolatile memory **85**. The density correction values include gradation correction values (gamma correction values) and bias correction values. The CPU **81** causes the image forming section **30** to form the pattern for position acquisition, while correcting image forming positions and image densities of the pattern according to the most-recently set position correction values and density correction values that are stored in the nonvolatile memory **85**. That is, the CPU **81** corrects the image forming positions by correcting the timings of exposure onto the photosensitive bodies **40** by the exposure units **32** based on the position correction values. The CPU **81** corrects the image densities of the pattern by changing gradations in image data for the pattern based on the gradation correction values and by changing the developing bias values applied to the developing rollers **38** based on the bias correction values.

In the pattern for position acquisition, a plurality of marks are arrayed in the sub scanning direction and are separated from each other by an interval in the sub scanning direction. Each mark is longer in the main scanning direction than in the sub scanning direction. The plurality of marks are divided into several groups of marks such that the groups are arranged in the sub scanning direction and are separated from each other by an interval in the sub scanning direction. In each group, four marks of black, yellow, magenta, and cyan are arranged in this order.

After having started to form the pattern for position acquisition on the belt **24**, in S**22** the CPU **81** causes the mark sensor **70** to execute the position detection operation described above, and acquires information related to positions of respective marks based on the detection results. Specifically, based on signals from the mark sensor **70**, the CPU **81** detects timings at which the respective marks pass the detection location X of the mark sensor **70**. Then, based on the detected timings, the CPU **81** acquires positional shift amounts in the sub scanning direction of the marks for colors other than black (hereafter referred to as correction colors), relative to the black marks whose positions are used as a reference.

After acquiring the positional shift amounts for all groups of marks, the CPU **81** calculates an average value, across all groups of marks, of the positional shift amounts for each correction color. The CPU **81** then in S**23** updates the position correction value stored in the nonvolatile memory **85** for each correction color by adding to the position correction value such a value that serves to cancel out a positional deviation (color registration deviation) that is a difference between the average value and a reference shift amount for the correction color. The reference shift amount for each correction color is a positional shift amount between a black mark and a mark of the correction color in an ideal case in which no positional deviation occurs. The CPU **81** then terminates the cleaning-and-correction control processing.

(2-2) Density Acquisition Processing

If the CPU **81** determines that the density acquisition execution condition is satisfied (S**20**: YES), in S**24** and S**25** the CPU **81** executes density acquisition processing. Specifically, in S**24** the CPU **81** causes the image forming section **30** to form the pattern for density acquisition on the belt **24**, while correcting the image forming positions and image densities based on the most-recently set position correction values and density correction values that are stored in the nonvolatile memory **85**. In the pattern for density acquisition, a plurality of marks are arrayed in the sub scanning direction and are separated from each other by an interval in the sub scanning direction. Each mark has a substantially rectangular shape. The pattern for density acquisition is configured from four gradation patterns each for one color. Each gradation pattern is composed of several marks whose image densities progressively change by a prescribed density interval (for example, 20%).

After having started to form the pattern for density acquisition on the belt **24**, in S**25** the CPU **81** acquires information related to the image densities of the respective marks based on the detection results of the sensor **70**. Specifically, based on signals from the mark sensor **70**, the CPU **81** detects the amount of light reflected from the belt **24** when each mark passes the detection location X of the mark sensor **70**. Based on the detection results, the CPU **81** acquires the image densities of each gradation pattern.

After having acquired the image densities for all the marks, in S**26** the CPU **81** updates the bias correction value stored in the nonvolatile memory **85** for each color by modifying the bias correction value such that an image density value detected for a mark having an image density of 100% will become a predetermined ideal density value. Also in S**26** the CPU **81** updates the gradation correction value stored in the nonvolatile memory **85** for each color by modifying the gradation correction value such that the changing characteristics of the image densities in the gradation pattern will approach such ideal image density characteristics which are faithful to an image corresponding to image data contained in the print command. The CPU **81** then terminates the cleaning-and-correction control processing.

Effects of the Present Embodiment

Now assume that the density pre-execution condition is satisfied at a time T0 as shown in FIG. **7**. According to the present embodiment, therefore, at the time T0, cleaning performance of the cleaning unit **60** is increased and the belt **24** is cleaned by the cleaning unit **60** with the enhanced cleaning performance. Thereafter, at time T1, the density acquisition execution condition is satisfied. Accordingly, at the time T1, the density acquisition processing is executed by using the belt **24** which has already been cleaned. The acquisition accuracy of image densities can be restrained from being degraded due to substances adhered to the belt **24**. It is noted that another configuration is conceivable in which, at the time T1 when the density acquisition execution condition is satisfied, the belt **24** is cleaned and then density acquisition processing is executed. However, in comparison with this conceivable configuration, the configuration of the present embodiment can execute the density acquisition processing more quickly after the density acquisition execution condition is satisfied.

Other Embodiments

While the invention has been described in detail with reference to the embodiment thereof, it would be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention.

For example, the present invention can be applied not only to the direct-to-paper transfer tandem type printers, but also to printers of other various types, such as, intermediate transfer type printers, and 4-cycle transfer type printers. In these printers, photosensitive bodies bear thereon electrostatic images and toner images, and therefore are examples of a bearing body, and developing units, charging units, and exposure units are examples of an image forming section.

The present invention can be applied also to printers of other types, such as printers of a multi-transfer, intermediate transfer type, which employs an intermediate transfer body and is of a tandem type. In these printers, intermediate transfer bodies and photosensitive bodies bear thereon electrostatic images and toner images, and therefore are examples of a bearing body, and developing units, charging units, and exposure units are examples of an image forming section.

In addition, the present invention can be applied to electrophotographic printers of other types, such as of a polygon scanning type. The present invention can be applied to printers of other types, such as inkjet printers.

The present invention can be applied to such a printer whose image forming section can perform single-sided printing only. The present invention can be applied also to such a printer whose image forming section can perform monochrome printing only.

The cleaning unit **60** may be configured to physically recover substances adhered to the belt **24**. For example, the cleaning unit **60** may have a blade which serves as a contact body that can contact with the surface of the belt **24**. The blade is configured to physically scrape off substances adhered onto the belt **24**, thereby recovering the adhered substances. According to this configuration, cleaning performance can be enhanced by moving the blade from a state, in which the blade is out of contact with the belt **24**, to a state, in which the blade is in contact with the belt **24**. Or, cleaning performance can be enhanced by increasing the strength or amount of force with which the blade is pressed against the belt **24**.

The detection unit **70** may not be limited to the optical sensor, but may be configured from an image sensing device such as a CCD camera.

In the above-described embodiment, the controller **80** executes the cleaning-and-correction control processing and other processings by using a single CPU and memory. However, the present invention is not limited to this configuration. For example, the controller **80** may execute the cleaning-and-correction control processing and other processings: by using multiple CPUs; by using a hardware circuit such as the ASIC **84** only; or by using a CPU and a hardware circuit. Or, the controller **80** may execute the print control processing by using one CPU and execute the cleaning-and-correction control processing by using another CPU that is different from the CPU that is used to execute the print control processing.

In the embodiment, the printer **1** executes, as the pattern acquisition processing, the position acquisition processing and density acquisition processing. However, the printer **1** may execute, as the pattern acquisition processing, at least one of the processing I and the processing II described below:

<Processing I>

A pattern for detecting positions in the main scanning direction is formed on the belt **24** by the image forming section **30**. Positions of this pattern in the main scanning direction are acquired using an optical sensor such as the mark sensor **70**.

<Processing II>

A pattern for detecting variations in the rotation speed of the photosensitive bodies **40** is formed on the belt **24** by the image forming section **30**. Positions of this pattern, which correspond to the variations in the rotation speed, are acquired using an optical sensor such as the mark sensor **70**.

In the embodiment, the printer **1** acquires, as characteristics of a pattern image, the image forming positions in the sub scanning direction of the pattern image and the image densities of the pattern image. However, the printer **1** may acquire, as the characteristics of the pattern image, image forming positions of the pattern image in the main scanning direction, or image sizes (scaling) of the pattern image.

Each of the position acquisition execution condition and the density acquisition execution condition may include at least one of conditions 1 to 6 listed below.

Condition 1: That the cover **2**B has been opened at least a prescribed number of times.

The controller **80** can determine whether or not the condition 1 is satisfied, based on detection results of a cover open-close sensor (not shown). The number of times that the cover **2**B has opened and closed is an example of a correlation value.

Condition 2: That a prescribed length of time has elapsed since the last time that the pattern acquisition processing (the position acquisition processing or density acquisition processing) was executed.

The length of time, which has elapsed since the last time that the pattern acquisition processing (the position acquisition processing or density acquisition processing) was executed, is an example of a correlation value.

Condition 3: That the temperature within the casing **2** has become higher than or equal to a prescribed temperature.

The controller **80** can determine whether or not the condition 3 is satisfied based on detection results of a temperature sensor (not shown). The temperature within the casing **2** is an example of a correlation value.

Condition 4: That the humidity within the casing **2** has become higher than or equal to a prescribed humidity. The humidity within the casing **2** is an example of a correlation value.

Condition 5: That the total number of sheets **3**, which have been printed since the last time that the pattern acquisition processing (the position acquisition processing or density acquisition processing) was executed, has become higher than or equal to a prescribed number. The total number of sheets **3**, which have been printed since the last time that the pattern acquisition processing was executed, is an example of a correlation value.

Condition 6: That the total number of rotations of the belt **24** or the photosensitive bodies **40**, which have occurred since the last time that the pattern acquisition processing (the position acquisition processing or density acquisition processing) was executed, has become higher than or equal to a prescribed number. The total number of rotations of the belt **24** or the photosensitive bodies **40**, which have occurred since the last time that the pattern acquisition processing was executed is an example of a correlation value.

It is sufficient that the correlation value is such a value that is correlated with the amount of deviation in characteristics of images formed by the image forming section **30** from ideal characteristics. Accordingly, the correlation values in the respective conditions 1-6 described above may be converted into point values, and the total of the point values may be used as a correlation value.

The belt drive condition, for which judgment is executed in **S11**, is not limited to the condition that a print command has been received. Now suppose that the printer **1** is provided with an agitator (not shown) for agitating the toner in the toner accommodating chamber **36** to maintain fluidity of toner. The agitator is configured to rotate in association with the driving rotation of the belt **24**. In this case, the belt drive condition may be such a condition that the time to agitate toner in the toner accommodating chamber **36** has arrived. If this condition is satisfied, the belt **24** is started to be driven to rotate. The time to perform toner agitation may be reached when the power is turned on, or when the remaining amount of toner is detected.

The belt drive condition may also be a condition that the time to execute sensitivity adjustment of the mark sensor **70** has arrived. The time to execute the sensitivity adjustment of the mark sensor **70** may be reached when the power is turned on, or when a prescribed amount of time has elapsed since the last time that the sensitivity adjustment was performed. When the time to execute sensitivity adjustment has arrived, the controller **80** starts driving the belt **24** to rotate, and causes the mark sensor **70** to execute light projection onto and light reception from the surface of the belt **24**. The controller **80** adjusts sensitivity of the mark sensor **70** by changing the amount of the projected light based on the light reception results.

The belt stop condition, for which judgment is executed in S**108**, may be a condition that some processing has completed. Or, the belt stop condition may be a condition that an error has occurred due to a sheet being printed has become jammed on the conveyance path or due to there being no sheets **3** loaded in the tray **11**.

The first cleaning voltage may be applied to the cleaning roller **61** before the processing in S**107** is executed. In such a case, the CPU **81** can enhance the cleaning performance in S**107** by increasing the absolute value of the first cleaning voltage.

Or, before the processing of S**107** is executed, the cleaning roller **61** may be applied with a voltage whose polarity is such a polarity that is incapable of recovering adhered substances from the belt **24** (positive polarity, for example). In S**107**, the CPU **81** can enhance the cleaning performance by switching the polarity of the voltage to such a polarity that is capable of recovering the adhered substances (negative polarity, for example).

Or, in S**107**, the CPU **81** can enhance the cleaning performance by starting to drive the cleaning roller **61** to rotate. Or, in S**107**, the CPU **81** can enhance the cleaning performance by increasing a length of time during which the cleaning unit **60** is kept being turned on. The length of time during which the cleaning unit **60** is kept being turned on can be increased by lowering the adhesion threshold used in S**104**, for example.

In the cleaning-and-correction control processing in FIG. **4**, the CPU **81** may proceed directly to S**12**, without executing S**11**, that is, regardless of whether or not the belt **24** is being driven to rotate.

The position pre-execution condition and the density pre-execution condition may not include condition B. If the CPU **81** determines in S**13** that at least one of conditions A and C is satisfied (S**13**: YES), the CPU **81** may proceed directly to S**107** in FIG. **5**, without executing S**101** to S**104**, thereby increasing the cleaning performance of the cleaning unit **60**.

In the cleaning control processing, after causing the light projection part **70**A to start emitting light in S**101**, the CPU **81** may proceed directly to S**103**, without performing the adhesion threshold configuration process in S**102**. That is, the adhesion threshold may be a fixed value.

The CPU **81** may change the adhesion threshold such that the adhesion threshold becomes lowered as the cleaning-on time of the cleaning unit **60** which has been measured since the printer **1** was new increases. Or, CPU **81** may change the adhesion threshold such that the adhesion threshold becomes lowered as the numbers of rotations of the belt **24** and the cleaning roller **61** which have occurred since the printer **1** was new increase. This is because as the cleaning-on time of the cleaning unit **60** increases and as the numbers of rotations of the belt **24** and cleaning roller **61** increase, the degree of deterioration in the cleaning roller **61** increases, and the cleaning performance decreases. This modification can cause the cleaning unit **60** to perform cleaning even if the degree of adhesion of substances on the belt **24** is somewhat low. This can restrain the deteriorated cleaning unit **60** from failing to clean the belt **24** sufficiently.

If the CPU **81** determines that the belt stop condition is satisfied (S**108**: YES), the CPU **81** may set in S**105** the cleaning performance of the cleaning unit **60** to such a level that is no higher than the level which the cleaning unit **60** possessed before the belt **24** started to be driven to rotate. Or, the CPU **81** may set in S**105** the cleaning performance to such a level that is higher than the level which the cleaning unit **60** possessed before the belt **24** started to be driven to rotate, but lower than the level which the cleaning unit **60** possessed before the belt stop condition became satisfied.

In the cleaning control processing, after turning on the cleaning unit **60** in S**107**, the CPU **81** may proceed directly to S**103**, without executing the process of S**108**. In other words, the CPU **81** may turn on the cleaning unit **60** if the belt drive condition is satisfied, and keep the cleaning unit **60** on until the degree of adhesion becomes smaller than or equal to the adhesion threshold, regardless of whether the belt **24** is rotating or not.

In the adhesion threshold configuration processing, the CPU **81** may execute only one of the decision steps S**202** and S**205**. For example, the CPU **81** may skip the decision step S**201** and proceed directly to either S**202** or S**205**, regardless of whether or not at least one of the conditions A and C is satisfied. Or, instead of executing the process of S**201**, the CPU **81** may determine which of the conditions A and C is satisfied. The CPU **81** may proceed to S**204** if only condition A is satisfied. The CPU **81** may proceed to S**203** if only condition C is satisfied.

In each of S**203** and S**206** in FIG. **6**, the CPU **81** may execute only one from among: the setting to set the adhesion threshold to the low threshold TH1 or TH3; and the setting to set the cleaning performance level to the high level P1 or P3.

Similarly, in each of S**204** and S**207** in FIG. **6**, the CPU **81** may execute only one from among: the setting to set the adhesion threshold to the high threshold TH2 or TH4; and the setting to set the cleaning performance level to the low level P2 or P4.

The printer **1** may be configured such that the photosensitive bodies **40** can be separated away from the belt **24**. In such a case, it is preferable that the CPU **81** individually detects: the number of rotations of the photosensitive bodies **40** which have occurred since the last time that the cleaning unit **60** was turned off; and the number of rotations of the belt **24** which have occurred since the last time that the cleaning unit **60** was turned off. The CPU **81** may set the deterioration threshold such that the higher the rotation numbers, the lower the deterioration threshold.

In S**16** in FIG. **4**, the CPU **81** may set the deterioration threshold based on at least one of: the humidity; the number of rotations of the photosensitive bodies **40** which have occurred since the last time that the cleaning unit **60** was turned off; and the number of rotations of the belt **24** which have occurred since the last time that the cleaning unit **60** was turned off. Or, the CPU **81** may skip the processing of S**16**. That is, the deterioration threshold may be a fixed value.

The condition "the correlation value becomes higher than or equal to the execution threshold" means that the absolute value of the correlation value becomes higher than or equal to the absolute value of the execution threshold. For example, the correlation value and the execution threshold may both be negative values. In such a case, the condition "the correlation value becomes higher than or equal to the execution threshold" includes such a condition that the correlation value becomes lower than or equal to the execution threshold. Similarly, the condition "the correlation value becomes higher than or equal to the pre-execution threshold" means that the absolute value of the correlation value becomes higher than or equal to the absolute value of the pre-execution threshold. For example, the correlation value and the pre-execution threshold may both be negative values. In such a case, the condition "the correlation value becomes higher than or equal to the pre-execution threshold" includes such a condition that the correlation value becomes lower than or equal to the pre-execution threshold.

"A pre-execution threshold lower than the execution threshold" means a pre-execution threshold whose absolute value is less than that of the execution threshold. Thus, if the execution threshold and the pre-execution threshold are both negative, the pre-execution threshold is higher than the execution threshold.

What is claimed is:

1. An image forming apparatus comprising:

a bearing body;

an image forming section configured to form an image on the bearing body;

a detection unit configured to output detection results that correspond to a state of a surface of the bearing body;

a cleaning unit configured to clean the bearing body, the cleaning unit being configured to be brought into a first state and a second state different from the first state, the cleaning unit in the first state attaining a first cleaning performance level, the cleaning unit in the second state attaining a second cleaning performance level that is higher than the first cleaning performance level; and

a control device configured to:

execute a pre-execution condition determination to determine whether a pre-execution condition is satisfied;

when it is determined that the pre-execution condition is satisfied, bring the cleaning unit from the first state into the second state and control the cleaning unit to clean the bearing body;

execute an execution condition determination to determine whether an execution condition is satisfied; and

when it is determined that the execution condition is satisfied, execute a pattern acquisition for forming a pattern image on the bearing body by using the image forming section and acquiring characteristics of the pattern image based on detection results that are outputted from the detection unit by detecting the pattern image,

the pre-execution condition including a condition that a correlation value satisfies a first condition,

the correlation value being correlated with an amount of deviation in characteristics of images formed by the image forming section,

the execution condition including a condition that the correlation value satisfies a second condition,

the correlation value satisfying the first condition before satisfying the second condition,

in the pre-execution condition determination, the control device is configured to determine whether at least one of a position pre-execution condition and a density pre-execution condition is satisfied,

the position pre-execution condition includes a condition that a position correlation value satisfies a first position-related condition,

the density pre-execution condition includes a condition that a density correlation value satisfies a first density-related condition,

the control device is configured to bring the cleaning unit from the first state into the second state when it is determined that at least one of the density pre-execution condition and the position pre-execution condition is satisfied,

the second cleaning performance level of the second state, into which the control device brings the cleaning unit when it is determined that the density pre-execution condition is satisfied, is higher than the second cleaning performance level of the second state, into which the control device brings the cleaning unit when it is determined that the position pre-execution condition is satisfied,

in the execution condition determination, the control device is configured to determine whether at least one of a position acquisition execution condition and a density acquisition execution condition is satisfied,

the control device is configured to execute a position acquisition as the pattern acquisition when it is determined that the position acquisition execution condition is satisfied and to execute a density acquisition as the pattern acquisition when it is determined that the density acquisition execution condition is satisfied,

the position acquisition execution condition includes a condition that the position correlation value satisfies a second position-related condition,

the density acquisition execution condition includes a condition that the density correlation value satisfies a second density-related condition,

the position acquisition being for forming a position acquisition pattern image on the bearing body by using the image forming section and acquiring a position of the position acquisition pattern image based on detection results that are outputted from the detection unit by detecting the position acquisition pattern image,

the density acquisition being for forming a density acquisition pattern image on the bearing body by using the image forming section and acquiring an image density of the density acquisition pattern image based on detection results that are outputted from the detection unit by detecting the density acquisition pattern image,

the position correlation value being correlated with an amount of deviation in positions of images formed by the image forming section,

the density correlation value being correlated with an amount of deviation in densities of images formed by the image forming section,

the position correlation value satisfying the first position-related condition before satisfying the second position-related condition, and

the density correlation value satisfying the first density-related condition before satisfying the second density-related condition.

2. The image forming apparatus according to claim **1**,

wherein the bearing body includes a rotating body configured to be driven to rotate,

wherein the image forming apparatus further comprises:

a reception unit configured to receive a formation command; and

a driving unit configured to drive the rotating body to rotate, and

wherein the control device is configured such that when the reception unit receives a formation command, the control device executes an image formation for controlling the driving unit to drive the rotating body to rotate and controlling the image forming section to form images based on the formation command, the control device being configured to bring the cleaning unit into the second state after the driving unit has started driving the rotating body to rotate.

3. The image forming apparatus according to claim **2**, wherein:

the control device is configured to control the image forming section and the bearing body to perform both of a single-sided image formation and a double-sided image formation, the single-sided image formation being for forming an image on one side of a sheet conveyed on the bearing body, the double-sided image formation being for forming an image on one side of a sheet conveyed on the bearing body and forming an image on another side of the sheet that is conveyed on the bearing body with its sides being reversed, and

the second cleaning performance level of the second state, into which the control device brings the cleaning unit when the formation command specifies the double-sided printing, is higher than the second cleaning performance level of the second state, into which the control device brings the cleaning unit when the formation command specifies the single-sided printing.

4. The image forming apparatus according to claim **1**, wherein:

the control device is configured to:

when it is determined that neither the position pre-execution condition nor the density pre-execution condition is satisfied, execute a deterioration determination for determining whether a degree of deterioration of the cleaning unit exceeds a reference deterioration value, and

when it is determined that the degree of deterioration exceeds the reference deterioration value, execute a deterioration-time cleaning for bringing the cleaning unit from the first state into the second state and controlling the cleaning unit to clean the bearing body, the deterioration-time cleaning being executed before at least one of the position pre-execution condition and the density pre-execution condition is satisfied.

5. The image forming apparatus according to claim **4**, further comprising a humidity detection unit configured to detect humidity,

wherein the control device is configured to set the reference deterioration value such that the reference deterioration value decreases as the humidity decreases.

6. The image forming apparatus according to claim **4**,

wherein the image forming section comprises:

an accommodating part configured to accommodate coloring agent; and

an image bearing body configured to rotate while being in contact with the bearing body and to form, as the images, images of the coloring agent on the bearing body, and

wherein the control device is configured to set the reference deterioration value such that the reference deterioration value decreases as the number of rotations of the image bearing body, which have occurred since a reference time, increases.

7. The image forming apparatus according to claim **4**, wherein:

the bearing body includes a rotating body configured to be driven to rotate,

the cleaning unit is in continuous contact with the rotating body, and

the control device is configured to set the reference deterioration value such that the reference deterioration value decreases as the number of rotations of the rotating body, which have occurred since a reference time, increases.

8. The image forming apparatus according to claim **1**, wherein the cleaning unit in the first state is out of contact with the bearing body, and the cleaning unit in the second state is in contact with the bearing body.

9. The image forming apparatus according to claim **1**, wherein:

the cleaning unit in both of the first and second states is in contact with the bearing body,

the cleaning unit in the first state is pressed against the bearing body with force of a first amount, and

the cleaning unit in the second state is pressed against the bearing body with force of a second amount that is greater than the first amount.

10. The image forming apparatus according to claim **1**, wherein the cleaning unit in the first state is applied with no electric voltage, and the cleaning unit in the second state is applied with an electric voltage.

11. An image forming apparatus comprising:

a bearing body;

an image forming section configured to form an image on the bearing body;

a detection unit configured to output detection results that correspond to a state of a surface of the bearing body;

a cleaning unit configured to clean the bearing body, the cleaning unit being configured to be brought into a first state and a second state different from the first state, the cleaning unit in the first state attaining a first cleaning performance level, the cleaning unit in the second state attaining a second cleaning performance level that is higher than the first cleaning performance level; and

a control device configured to:

execute a pre-execution condition determination to determine whether a pre-execution condition is satisfied;

when it is determined that the pre-execution condition is satisfied, bring the cleaning unit from the first state into the second state and control the cleaning unit to clean the bearing body;

execute an execution condition determination to determine whether an execution condition is satisfied; and

when it is determined that the execution condition is satisfied, execute a pattern acquisition for forming a pattern image on the bearing body by using the image forming section and acquiring characteristics of the pattern image based on detection results that are outputted from the detection unit by detecting the pattern image,

the pre-execution condition including a condition that a correlation value satisfies a first condition,

the correlation value being correlated with an amount of deviation in characteristics of images formed by the image forming section,

the execution condition including a condition that the correlation value satisfies a second condition,

the correlation value satisfying the first condition before satisfying the second condition,

wherein the control device is configured to execute a detection for detecting a degree of adhesion of substances on the bearing body based on detection results of the detection unit, and

wherein the pre-execution condition includes a condition that the correlation value satisfies the first condition and the detected degree of adhesion exceeds a reference adhesion degree.

12. The image forming apparatus according to claim 11, wherein:

in the pre-execution condition determination, the control device is configured to determine whether at least one of a position pre-execution condition and a density pre-execution condition is satisfied,

the position pre-execution condition includes a condition that a position correlation value satisfies a first position-related condition and the detected degree of adhesion exceeds a position-related reference adhesion degree,

the density pre-execution condition includes a condition that a density correlation value satisfies a first density-related condition and the detected degree of adhesion exceeds a density-related reference adhesion degree,

the density-related reference adhesion degree is smaller than the position-related reference adhesion degree,

the control device is configured to bring the cleaning unit from the first state into the second state when it is determined that at least one of the density pre-execution condition and the position pre-execution condition is satisfied,

in the execution condition determination, the control device is configured to determine whether at least one of a position acquisition execution condition and a density acquisition execution condition is satisfied,

the control device is configured to execute a position acquisition as the pattern acquisition when it is determined that the position acquisition execution condition is satisfied and to execute a density acquisition as the pattern acquisition when it is determined that the density acquisition execution condition is satisfied,

the position acquisition execution condition includes a condition that the position correlation value satisfies a second position-related condition,

the density acquisition execution condition includes a condition that the density correlation value satisfies a second density-related condition,

the position acquisition being for forming a position acquisition pattern image on the bearing body by using the image forming section and acquiring a position of the position acquisition pattern image based on detection results that are outputted from the detection unit by detecting the position acquisition pattern image,

the density acquisition being for forming a density acquisition pattern image on the bearing body by using the image forming section and acquiring an image density of the density acquisition pattern image based on detection results that are outputted from the detection unit by detecting the density acquisition pattern image,

the position correlation value being correlated with an amount of deviation in positions of images formed by the image forming section,

the density correlation value being correlated with an amount of deviation in densities of images formed by the image forming section,

the position correlation value satisfying the first position-related condition before satisfying the second position-related condition,

the density correlation value satisfying the first density-related condition before satisfying the second density-related condition.

13. An image forming apparatus comprising:

a bearing body;

an image forming section configured to form an image on the bearing body;

a detection unit configured to output detection results that correspond to a state of a surface of the bearing body;

a cleaning unit configured to clean the bearing body, the cleaning unit being configured to be brought into a first state and a second state different from the first state, the cleaning unit in the first state attaining a first cleaning performance level, the cleaning unit in the second state attaining a second cleaning performance level that is higher than the first cleaning performance level; and

a control device configured to:

execute a pre-execution condition determination to determine whether a pre-execution condition is satisfied;

when it is determined that the pre-execution condition is satisfied, bring the cleaning unit from the first state into the second state and control the cleaning unit to clean the bearing body;

execute an execution condition determination to determine whether an execution condition is satisfied; and

when it is determined that the execution condition is satisfied, execute a pattern acquisition for forming a pattern image on the bearing body by using the image forming section and acquiring characteristics of the pattern image based on detection results that are outputted from the detection unit by detecting the pattern image,

the pre-execution condition including a condition that a correlation value satisfies a first condition,

the correlation value being correlated with an amount of deviation in characteristics of images formed by the image forming section,

the execution condition including a condition that the correlation value satisfies a second condition, and

the correlation value satisfying the first condition before satisfying the second condition,

wherein the correlation value changes such that after having satisfied the first condition, the correlation value continues to satisfy the first condition until the correlation value begins satisfying the second condition.

14. The image forming apparatus according to claim 13, wherein:

it is determined that the correlation value satisfies the first condition when an absolute value of the correlation value becomes higher than or equal to an absolute value of a pre-execution threshold,

it is determined that the correlation value satisfies the second condition when the absolute value of the correlation value becomes higher than or equal to an absolute value of an execution threshold,

the absolute value of the pre-execution threshold is lower than the absolute value of the execution threshold, and

the absolute value of the correlation value changes such that after becoming higher than or equal to the absolute value of the pre-execution threshold, the absolute value of the correlation value remains higher than or equal to the absolute value of the pre-execution threshold until the absolute value of the correlation value becomes higher than or equal to the absolute value of the execution threshold.

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